Subpart N—Emission Regulations for New Otto-Cycle and Diesel Heavy-Duty Engines; Gaseous and Particulate Exhaust Test Procedures

§ 86.1301–90 Scope; applicability.

This subpart contains gaseous emission test procedures for Otto-cycle and diesel heavy-duty engines, and particulate emission test procedures for diesel heavy-duty engines. It applies to 1990 and later model years.

[54 FR 14571, Apr. 11, 1989]

§ 86.1302–84 Definitions.

The definitions in § 86.084–2 apply to this subpart.

§ 86.1303–84 Abbreviations.

The abbreviations in § 86.084–3 apply to this subpart.

§ 86.1304–90 Section numbering; construction.

(a) The model year of initial applicability is indicated by the section number. The two digits following the hyphen designate the first model year for which a section is effective. A section remains effective until superseded.

Example: Section 86.1311–84 applies to the 1984 and subsequent model years until superceded. If a § 86.1311–88 is promulgated it would take effect beginning with the 1988 model year; § 86.1311–84 would apply to model years 1984 through 1987.

(b) A section reference without a model year suffix refers to the section applicable for the appropriate model year.

(c) Unless indicated, all provisions in this subpart apply to both Otto-cycle and diesel heavy-duty engines.

[54 FR 14571, Apr. 11, 1989]

§ 86.1305–90 Introduction; structure of subpart.

(a) This subpart describes the equipment required and the procedures to follow in order to perform exhaust emission tests on Otto-cycle and diesel heavy-duty engines. Subpart A sets forth the testing requirements and test intervals necessary to comply with EPA certification procedures.

(b) Four topics are addressed in this subpart. Sections 86.1306 through 86.1315 set forth specifications and equipment requirements; §§ 86.1316 through 86.1326 discuss calibration methods and frequency; test procedures are listed in §§ 86.1327 through 86.1341; calculation formula are found in § 86.1342; and data requirements are found in § 86.1344.

[54 FR 14571, Apr. 11, 1989]

§ 86.1306–90 Equipment required and specifications; overview.

(a) *Exhaust emission tests.* All engines subject to this subpart are tested for exhaust emissions. Petroleum-fueled, natural gas-fueled, liquefied petroleum gas-fueled and methanol-fueled, Otto-cycle and diesel engines are tested identically with the exception of the systems used to measure hydrocarbon, nitrogen oxide, methanol, formaldehyde and particulate; petroleum-fueled diesel engines require a heated, continuous hydrocarbon detector and a continuous nitrogen oxide detector (§ 86.1310); methanol-fueled engines require a heated hydrocarbon detector, a methanol detector and a formaldehyde detector; either a heated or a non-heated continuous hydrocarbon detector may be used with natural gas-fueled and liquefied petroleum gas-fueled diesel engines; gasoline-fueled, natural gas-fueled, liquefied petroleum gas-fueled and methanol-fueled Otto-cycle engines are not tested for particulate emissions (§ 86.1309). Necessary equipment and specifications appear in §§ 86.1308, 86.1309, 86.1310 and 86.1311.

(b) *Fuel, analytical gas, and engine cycle specifications.* Fuel specifications for exhaust emission testing are specified in § 86.1313. Analytical gases are specified in § 86.1314. The EPA heavy-duty transient engines cycles for use in exhaust testing are described in § 86.1333 and specified in appendix I to this part.

[54 FR 14572, Apr. 11, 1989, as amended at 59 FR 48525, Sept. 21, 1994]

§ 86.1306–96 Equipment required and specifications; overview.

(a) *Exhaust emission tests.* All engines subject to this subpart are tested for exhaust emissions. Petroleum-, natural gas-, liquefied petroleum gas-, and methanol-fueled Otto-cycle and diesel engines are tested identically with two exceptions. First, the systems used to measure hydrocarbon, nitrogen oxide, methanol, formaldehyde and particulate depend on the type of engine being tested; petroleum-fueled diesel engines require a heated, continuous hydrocarbon detector and a heated, continuous nitrogen oxide detector (see § 86.1310); methanol-fueled engines require a heated hydrocarbon detector, a methanol detector and a formaldehyde detector; either a heated or non-heated continuous hydrocarbon detector may be used with natural gas-fueled and liquefied petroleum gas-fueled diesel engines; gasoline-fueled, natural gas-fueled, liquefied petroleum gas-fueled and methanol-fueled Otto-cycle engines are not tested for particulate emissions (see § 86.1309). Second, if a gasoline-fueled and methanol-fueled engine is to be used in a vehicle equipped with an evaporative canister, the test engine must have a loaded evaporative canister attached for the exhaust emission test. Necessary equipment and specifications appear in §§ 86.1308, 86.1309, 86.1310 and 86.1311.

(b) *Fuel, analytical gas, and engine cycle specifications.* Fuel specifications for exhaust emission testing are specified in § 86.1313. Analytical gases are specified in § 86.1314. The EPA heavy-duty transient engine cycles for use in exhaust testing are described in § 86.1333 and specified in appendix I to this part.

[58 FR 16064, Mar. 24, 1993, as amended at 59 FR 48525, Sept. 21, 1994]

§ 86.1308–84 Dynamometer and engine equipment specifications.

(a) *Engine dynamometer.* The engine dynamometer system must be capable of controlling engine torque and rpm simultaneously over transient cycles. The transient torque and rpm schedules described in § 86.1333–84 and specified in appendix I ((f)(i), (2), and (3)) must be followed within the accuracy requirements specified in § 86.1341–84. In addition to these general requirements, the engine or dynamometer readout signals for speed and torque shall meet the following accuracy specifications:

(1) Engine speed readout shall be accurate to within ±2 percent of the absolute standard value, as defined in paragraph (d) of this section.

(2) Engine flywheel torque readout shall be accurate to either within ±3 percent of the NBS ''true'' value torque (as defined in paragraph (e) of this section), or the following accuracies:

(i) ±2.5 ft-lbs. of the NBS ''true'' value if the full scale value is 550 ft-lbs. or less.

(ii) ±5 ft-lbs. of the NBS ''true'' value if the full scale value is 1050 ft-lbs. or less.

(iii) ±10 ft.-lbs., of the NBS ''true'' value if the full scale value is greater than 1050 ft.-lbs.

(3) *Option:* Internal dynamometer signals (i.e., armature current, etc.) may be used for torque measurement provided that it can be shown that the engine flywheel torque during the test cycle conforms to the accuracy specifications in paragraph (a) of this section. Such a measurement system must include compensation for increased or decreased flywheel torque due to the armature inertia during accelerations and decelerations in the test cycle.

(b) *Cycle verification equipment.* In order to verify that the test engine has followed the test cycle correctly, the dynamometer or engine readout signals for speed and torque must be collected in a manner that allows a statistical correlation between the actual engine performance and the test cycle (See § 86.1341–84). Normally this collection process would involve conversion of analog dynamometer or engine signals into digital values for storage in a computer. The conversion of dynamometer or engine values (computer or other) that are used to evaluate the validity of engine performance in relation to the test cycle shall be performed in a manner such that:

(1) Speed values used for cycle evaluation are accurate to within 2 percent of the dynamometer or engine flywheel torque readout value.

(2) Engine flywheel torque values used for cycle evaluation are accurate

to within 2 percent of the dynamometer or engine flywheel torque readout value.

(c) *Option:* For some systems it may be more convenient to combine the tolerances in paragraphs (a) and (b) of this section. This is permitted if the root mean square method (RMS) is used. The RMS values would then refer to accuracy in relationship to absolute standard or to NBS ''true'' values.

(1) Speed values used for cycle evaluation shall be accurate to within ±2.8 percent of the absolute standard values, as defined in paragraph (d) of this section.

(2) Engine flywheel torque values used for cycle evaluation shall be accurate to within ±3.6 percent of NBS ''true'' values, as determined in paragraph (e) of this section.

(d) *Speed calibration equipment.* A 60-tooth (or greater) wheel in combination with a common mode rejection frequency counter is considered an absolute standard for engine or dynamometer speed.

(e) *Torque calibration equipment.* Two techniques are allowed for torque calibration. Alternate techniques may be used if shown to yield equivalent accuracies. The NBS ''true'' value torque is defined as the torque calculated by taking the product of an NBS traceable weight or force and a sufficiently accurate horizontal lever arm distance, corrected for the hanging torque of the lever arm.

(1) The lever-arm dead-weight technique involves the placement of known weights at a known horizontal distance from the center of rotation of the torque measuring device. The equipment required is:

(i) *Calibration weights.* A minimum of six calibration weights for each range of torque measuring device used are required. The weights must be approximately equally spaced and each must be traceable to NBS weights. Laboratories located in foreign countries may certify calibration weights to local government bureau standards. Certification of weight by state government Bureau of Weights and Measures is acceptable. Effects of changes in gravitational constant at the test site may be accounted for if desired.

(ii) *Lever arm.* A lever arm with a minimum length of 24 inches is required. The horizontal distance from the centerline of the engine torque measurement device to the point of weight application shall be accurate to within ±0.10 inches. The arm must be balanced, or the hanging torque of the arm must be known to within ±0.1 ft-lbs.

(2) The transfer technique involves the calibration of a master load cell (i.e., dynamometer case load cell). This calibration can be done with known calibration weights at known horizontal distances, or by using a hydraulically actuated precalibrated master load cell. This calibration is then transferred to the flywheel torque measuring device. The technique involves the following steps:

(i) A master load cell shall be either precalibrated or be calibrated per paragraph (e)(1)(i) of this section with known weights traceable to NBS, and used with the lever arm(s) specified in paragraph (e)(2)(ii) of this section. The dynamometer should be either running or vibrated during this calibration to minimize static hysteresis.

(ii) A lever arm(s) with a minimum length of 24 inches is (are) required. The horizontal distances from the centerline of the master load cell, to the centerline of the dynamometer, and to the point of weight or force application shall be accurate to within ±0.10 inches. The arm(s) must be balanced or the net hanging torque of the arm(s) must be known to within ±0.1 ft.-lbs.

(iii) Transfer of calibration from the case or master load cell to the flywheel torque measuring device shall be performed with the dynamometer operating at a constant speed. The flywheel torque measurement device readout shall be calibrated to the master load cell torque readout at a minimum of six loads approximately equally spaced across the full useful ranges of both measurement devices. (Note that good engineering practice requires that both devices have approximately equal useful ranges of torque measurement.) The transfer calibration shall be performed in a manner such that the accuracy requirements of paragraph (a)(2) of this

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section for the flywheel torque measurement device readout be met or exceeded.

(3) Other techniques may be used if shown to yield equivalent accuracy.

(f) *Diesel engines only.* If direct measurement of mass fuel consumption is chosen as an option in lieu of dilute exhaust CO_2 measurement, the fuel measurement device shall be accurate to within ±2 percent of actual mass fuel flow.

[48 FR 52210, Nov. 16, 1983, as amended at 49 FR 48142, Dec. 10, 1984; 52 FR 47870, Dec. 16, 1987]

§ 86.1309–90 Exhaust gas sampling system; Otto-cycle engines.

(a)(1) *General.* The exhaust gas sampling system described in this paragraph is designed to measure the true mass of gaseous emissions in the exhaust of either gasoline-fueled, natural gas-fueled, liquefied petroleum gas-fueled or methanol-fueled Otto-cycle engines. In the CVS concept of measuring mass emissions, two conditions must be satisfied; the total volume of the mixture of exhaust and dilution air must be measured, and a continuously proportioned volume of sample must be collected for analysis. Mass emissions are determined from the sample concentration and total flow over the test period.

(2) *Engine exhaust to CVS duct.* For methanol-fueled engines, reactions of the exhaust gases in the exhaust duct connected to the dilution tunnel (for the purposes of this paragraph, the exhaust duct excludes the length of pipe representative of the vehicle exhaust pipe) shall be minimized. This may be accomplished by:

(i) Using a duct of unrestricted length maintained at a temperature below 599 °F (315 °C). (Cooling capabilities as required); or

(ii) Using a smooth wall duct less than five feet long with no required heating (a maximum of two short flexible connectors are allowed under this option); or

(iii) Omitting the duct and performing the exhaust gas dilution function at the engine exhaust manifold, immediately after exhaust aftertreatment systems, or after a length of pipe representative of the vehicle exhaust pipe; or

(iv) Partial dilution of the exhaust gas prior to entering the dilution tunnel, which lowers the duct temperature below 599 °F (315 °C).

(3) *Positive displacement pump.* The Positive Displacement Pump Constant Volume Sampler (PDP–CVS), Figure N90–1 satisfies the first condition by metering at a constant temperature and pressure through the pump. The total volume is measured by counting the revolutions made by the calibrated positive displacement pump. The proportional samples for the bag sample, the methanol sample (Figure N90–2), and the formaldehyde sample (Figure N90–3), as applicable are achieved by sampling at a constant flow rate. For methanol-fueled engines, the sample lines for the methanol and formaldehyde samples are heated to prevent condensation. (Note: For 1990 through 1994 model year methanol-fueled engines, methanol and formaldehyde sampling may be omitted provided the bag sample (hydrocarbons and methanol) is analyzed using a HFID calibrated with methanol.)

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(4) *Critical flow venturi.* The operation of the Critical Flow Venturi Constant Volume Sampler (CFV–CVS), Figure N90–4 is based upon the principles of fluid dynamics associated with critical flow. The CFV system is commonly called a constant volume system (CVS) even though the flow varies. It would

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be more proper to call the critical flow venturi (CFV) system a constant proportion sampling system since proportional sampling throughout temperature excursions is maintained by use of a small CFVs in the sample lines. For engines requiring measurement of methanol and/or formaldehyde, one line supplies sample for the bag sample, another line supplies sample for the methanol sample, and a third line supplies sample for the formaldehyde sample. The lines for the methanol and formaldehyde samples are heated to prevent condensation with care being taken to ensure that the CFVs of the sample probes are not heated. (Note: For 1990 through 1994 model year methanol-fueled engines, methanol and formaldehyde sampling may be omitted provided the bag sample (hydrocarbons and methanol) is analyzed using a HFID calibrated with methanol. The variable mixture flow rate is maintained at choked flow, which is inversely proportional to the square root of the gas temperature, and is computed continuously. Since the pressure and temperature are the same at all venturi inlets, the sample volume is proportional to the total volume.)

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(5) *Electronic Flow Control.* The Electronic Flow Control Critical Flow Venturi Constant Volume Sampler (EFC–CFV–CVS) is identical to the CFV–CVS system, except that it uses electronic mass flow meters to maintain proportional sampling for methanol and

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formaldehyde. The flow rate of the exhaust plus dilution air and the sample flow rate are measured electronically. Proportionality is maintained by electronically controlled metering valves in the methanol and formaldehyde sample lines. Control of the valves is based on the electronic response of the flow meters. It is recommended that total flow sample volumes be measured by separate flow meters. For methanol-fueled engines, one line supplies sample for the bag sample, another line supplies sample for the methanol sample, and a third line supplies sample for the formaldehyde sample. The sample lines for methanol and for formaldehyde may both draw samples from a single static probe. The lines for the methanol and formaldehyde samples are heated to prevent condensation.

(6) *Other systems.* Other sampling and/or analytical systems including the systems described in § 86.1310 for petroleum-fueled diesel engines may be used if shown to yield equivalent results, and if approved in advance by the Administrator.

(7) Since various configurations can produce equivalent results, exact conformance with these drawings is not required. Additional components such as instruments, valves, solenoids, pumps and switches may be used to provide additional information and coordinate the functions of the component systems. Other components such as snubbers, which are not needed to maintain accuracy on some systems, may be excluded if their exclusion is based upon good engineering judgment.

(b) *Component description,* PDP–CVS. The PDP–CVS, Figure N90–1, consists of a dilution air filter and mixing assembly, heat exchanger, positive displacement pump, sampling systems (see Figure N90–2 for methanol sampling system and Figure N90–3 for formaldehyde sampling system) including sampling lines which are heated to prevent condensation in the case of the methanol-fueled engine, and associated valves, pressure and temperature sensors. The temperature of the sample lines shall be more than 5 °F (3 °C) above the maximum dew point of the mixture and less than 250 °F (121 °C). (It is recommended the they be maintained at 235± 15 °F (113 ±8 °C)). Heating

of the sample lines may be omitted, provided the methanol and formaldehyde sample collection systems are close coupled to the probes thereby preventing loss of sample due to cooling and resulting condensation in the sample lines. The PDP–CVS shall conform to the following requirements:

(1) Exhaust system backpressure must not be artificially lowered by the CVS or dilution air inlet system. Measurements to verify this should be made in the raw exhaust immediately upstream of the inlet to the CVS. (For diesel engines, this measurement should be made immediately upstream of the backpressure set device.) This verification requires the continuous measurement and comparison of raw exhaust static pressure observed during a transient cycle, both with and without the operating CVS. Static pressure measured with the operating CVS system shall remain within ±5 inches of water (1.2 kPa) of the static pressure measured without connection to the CVS, at identical moments in the test cycle. (Sampling systems capable of maintaining the static pressure to within ±1 inch of water (0.25 kPa) will be used by the Administrator if a written request substantiates the need for this closer tolerance.) This requirement is essentially a design specification for the CVS/dilution air inlet system, and should be performed as often as good engineering practice dictates (*e.g.,* after installation of an uncharacterized CVS, addition of an unknown inlet restriction on the dilution air, etc.).

(2) The gas mixture temperature, measured at a point immediately ahead of the positive displacement pump and after the heat exchanger, shall be maintained within ±10 °F (±5.6 °C) of the average operating temperature observed during the test. (The average operating temperature may be estimated from the average operating temperature from similar tests.) The temperature measuring system (sensors and readout) shall have an accuracy and precision of ±3.4 °F (1.9 °C).

(3) The pressure gauges shall have an accuracy and precision of ±3 mm Hg (0.4 kPa).

(4) The flow capacity of the CVS shall be large enough to eliminate water

condensation in the system. This is especially critical for methanol-fueled engines and may also be of concern with natural gas- and liquefied petroleum gas-fueled engines; see "Calculation of Emissions and Fuel Economy When Using Alternative Fuels," EPA 460/3–83–009. Dehumidifying the dilution air before entering the CVS is allowed. Heating is also allowed, provided:

(i) The air (or air plus exhaust gas) temperature does not exceed 250 °F, or 125 °F if particulate emissions are measured;

(ii) Calculation of the CVS flow rate necessary to prevent water condensation is based on the lowest temperature encountered in the CVS prior to sampling. (It is recommended that the CVS system be insulated when heated dilution air is used.);

(iii) The dilution ratio is sufficiently high to prevent condensation in bag samples as they cool to room temperature.

(5) Sample collection bags for dilution air and exhaust samples shall be of sufficient size so as not to impede sample flow. A single dilution air sample, covering the total test period, may be collected for the determination of methanol and formaldehyde background (where applicable).

(6) The methanol sample collection system and the formaldehyde sample collection system shall each be of sufficient capacity so as to collect samples of adequate size for analysis without significant impact on the volume of dilute exhaust passing through the PDP. The systems shall also comply with the following requirements that apply to the design of the systems, not to individual tests:

(i) The methanol system shall be designed such that, if a test engine emitted the maximum allowable level of methanol (based on all applicable standards) during the first phase of the test, the measured concentration in the primary impinger would exceed either 25 mg/l or a concentration equal to 25 times the limit of detection for the GC analyzer.

(ii) The formaldehyde system shall be designed such that, if a test engine emitted formaldehyde at a rate equal to twenty percent of the maximum allowable level of THCE (i.e., 0.2 g/Bhp-hr

for a 1.1 g/Bhp-hr THCE standard), or the maximum formaldehyde level allowed by a specific formaldehyde standard, whichever is less, during the first phase of the test, the concentration of formaldehyde in the DNPH solution of the primary impinger, or solution resulting from the extraction of the DNPH cartridge, shall exceed either 2.5 mg/l or a concentration equal to 25 times the limit of detection for the HPLC analyzer.

(iii) The methanol and formaldehyde systems shall be designed such that the primary impinger collects at least 90 percent of the analyte in the samples. The remaining analyte shall be collected by the secondary impinger. Sampling systems shall be identical for all phases.

(c) *Component description, CFV.* The CFV sample system, Figure N90–4, consists of a dilution air filter (optional) and mixing assembly, cyclone particulate separator (optional), unheated sampling ventures for the bag, methanol and formaldehyde samples, as applicable, heated sample lines to prevent condensation in the case of the methanol-fueled engine, critical flow venturi, and associated valves, pressure and temperature sensors. The temperature of the sample lines shall be more than 5 °F (3 °C) above the maximum dew point of the mixture and less than 250 °F (121 °C). (It is recommended the they be maintained at 235 ±15 °F (113 ± 8 °C)). Heating of the sample lines may be omitted, provided the methanol and formaldehyde sample collection systems are close coupled to the probes thereby preventing loss of sample due to cooling and resulting condensation in the sample lines. The CFV sample system shall conform to the following requirements:

(1) Static pressure variations in the raw exhaust shall conform to the specifications detailed in paragraph (b)(1) of this section.

(2) The temperature measuring system (sensors and readout) shall have an accuracy and precision of ±3.4 °F (±1.9 °C). The temperature measuring system used in a CVS without a heat exchanger shall have a response time of 1.50 seconds to 62.5 percent of a temperature change (as measured in hot silicone oil). There is no response time

requirement for a CVS equipped with a heat exchanger.

(3) The pressure measuring system (sensors and readout) shall have an accuracy and precision of ±3 mm Hg (0.4 kPa).

(4) The flow capacity of the CVS shall be large enough to eliminate water condensation in the system. This is especially critical for methanol-fueled engines and may also be of concern with natural gas- and liquefied petroleum gas-fueled engines; see ''Calculation of Emissions and Fuel Economy When Using Alternative Fuels,'' EPA 460/3–83–009. Dehumidifying the dilution air before entering the CVS is allowed. Heating is also allowed, provided:

(i) The air (or air plus exhaust gas) temperature does not exceed 250 °F, or 125 °F if particulate emissions are measured.

(ii) Calculation of the CVS flow rate necessary to prevent water condensation is based on the lowest temperature encountered in the CVS prior to sampling. (It is recommended that the CVS system be insulated when heated dilution air is used.)

(iii) The dilution ratio is sufficiently high to prevent condensation in bag samples as they cool to room temperature.

(5) Sample collection bags for dilution air and exhaust samples shall be of sufficient size so as not to impede sample flow. A single dilution air sample, covering the total test period, may be collected for the determination of methanol and formaldehyde background (where applicable).

(6) The methanol sample collection system and the formaldehyde sample collection system shall each be of sufficient capacity so as to collect samples of adequate size for analysis without significant impact on the volume of dilute exhaust passing through the CFV. The systems shall also comply with the following requirements that apply to the design of the systems, not to individual tests:

(i) The methanol system shall be designed such that, if a test engine emitted the maximum allowable level of methanol (based on all applicable standards) during the first phase of the test, the measured concentration in the primary impinger would exceed ei-

ther 25 mg/l or a concentration equal to 25 times the limit of detection for the GC analyzer.

(ii) The formaldehyde system shall be designed such that, if a test engine emitted formaldehyde at a rate equal to twenty percent of the maximum allowable level of THCE (i.e., 0.2 g/Bhp-hr for a 1.1 g/Bhp-hr THCE standard), or the maximum formaldehyde level allowed by a specific formaldehyde standard, whichever is less, during the first phase of the test, the concentration of formaldehyde in the DNPH solution of the primary impinger, or solution resulting from the extraction of the DNPH cartridge, shall exceed either 2.5 mg/l or a concentration equal to 25 times the limit of detection for the HPLC analyzer.

(iii) The methanol and formaldehyde systems shall be designed such that the primary impinger collects at least 90 percent of the analyte in the samples. The remaining analyte shall be collected by the secondary impinger. Sampling systems shall be identical for all phases of the test.

(d) *Component description, EFC–CFV.* The EFC–CFV sample system, is identical to the CFV system described in paragraph (c) of this section, with the addition of electronic flow controllers, metering valves, separate flow meters to totalize sample flow volumes (optional), for methanol and formaldehyde samples. Both samples may be drawn from a single static probe. The EFC sample system shall conform to the following requirements:

(1) All of the requirements of paragraph (c) of this section.

(2) The ratio of sample flow to CVS flow must not vary by more ±5 percent from the setpoint of the test.

(3) The sample flow totalizers shall meet the accuracy specifications of § 86.1320. Total sample flow volumes may be obtained from the flow controllers, with advance approval of the Administrator, provided that they can be shown to meet the accuracy specifications of § 86.1320.

§ 86.1310–90 Exhaust gas sampling and analytical system; diesel engines.

(a) *General.* The exhaust gas sampling system described in this paragraph is designed to measure the true mass of both gaseous and particulate emissions in the exhaust of petroleum-fueled, natural gas-fueled, liquefied petroleum gas-fueled and methanol-fueled heavy-duty diesel engines. This system utilizes the CVS concept (described in § 86.1309) of measuring the combined mass emissions of HC, CH_3OH and HCHO from methanol-fueled engines and CO, CO_2 and particulate from all fuel types. A continuously integrated system is required for THC (petroleum-fueled, natural gas-fueled, and liquefied petroleum gas-fueled engines) and NO_X (all engines) measurement, and is allowed for all CO and CO_2 measurements plus the combined emissions of CH_3OH, HCHO, and HC from methanol-fueled engines. Where applicable, separate sampling systems are required for methanol and for formaldehyde. The mass of gaseous emissions is determined from the sample concentration and total flow over the test period. The mass of particulate emissions is determined from a proportional mass sample collected on a filter and from the sample flow and total flow over the test period. As an option, the measurement of total fuel mass consumed over a cycle may be substituted for the exhaust measurement of CO_2. General requirements are as follows:

(1) This sampling system requires the use of a PDP–CVS and a heat exchanger, a CFV–CVS (or an EFC–CFV–CVS) with either a heat exchanger or electronic flow compensation. Figure N90–5 is a schematic drawing of the PDP system. Figure N90–6 is a schematic drawing of the CFV–CVS system.

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(2) The HC analytical system for petroleum-fueled diesel engines requires a heated flame ionization detector (HFID) and heated sample system (375 ±20 °F (191 ±11 °C)). For natural gas-fueled and liquefied petroleum gas-fueled diesel engines either a heated flame ionization detector and heated sample system as required for petro-leum fuel or a non-heated flame ionization detector may be used.

(3) Methanol-fueled engines require the use of a heated flame ionization detector (HFID) (235°±15 °F (113°±8 °C)) for hydrocarbon analysis. With a heated FID, the hydrocarbon analysis can be made on the bag sample and the methanol and formaldehyde analyses are

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performed on the samples collected for these purposes (Figures N90–2 and N90–3).

NOTE: For 1990 through 1994 model year methanol-fueled engines, methanol and formaldehyde sampling may be omitted provided the hydrocarbon plus methanol analyses are performed using a FID calibrated on methanol.

(4) For methanol-fueled engines, cooling or reaction of the exhaust gases in the exhaust duct connected to the dilution tunnel (for the purposes of this paragraph, the exhaust duct excludes the length of pipe representative of the vehicle exhaust pipe) shall be minimized. This may be accomplished by:

(i) Using a duct of unrestricted length maintained at a temperature below 599 °F (315 °C). (Heating and possibly cooling capabilities as required); or

(ii) Using a smooth wall duct less than five feet long with no required heating (a maximum of two short flexible connectors are allowed under this option); or

(iii) Omitting the duct and performing the exhaust gas dilution function at the engine exhaust manifold or immediately after exhaust aftertreatment systems, or after a length of pipe representative of the vehicle exhaust pipe; or

(iv) Partial dilution of the exhaust gas prior to entering the dilution tunnel, which lowers the duct temperature below 599 °F (315 °C).

(5) Heated sample lines are required for the methanol and formaldehyde samples (care must be taken to prevent heating of the sample probes unless compensation for varying flow rate is made). The sample collection lines shall be heated to a temperature more than 5 °F (3 °C) above the maximum dew point of the mixture, but below 250 °F (121 °C).

(6) The CO and CO_2 analytical system requires:

(i) Bag sampling (§ 86.1309) and analytical (§ 86.1311) capabilities, as shown in Figure N90–5 (or Figure N90–6), or

(ii) Continuously integrated measurement of diluted CO and CO_2 meeting the minimum requirements and technical specifications contained in paragraph (b)(5) of this section. Unless compensation for varying flow is made, a

constant flow system must be used to ensure a representative sample.

(7) The NO_X analytical system requires a continuously integrated measurement of diluted NO_X meeting the minimum requirements and technical specifications contained in paragraph (b)(5) of this section. Unless compensation for varying flow is made, a constant flow system must be used to ensure a representative sample.

(8) The mass of particulate in the exhaust is determined via filtration. The particulate sampling system requires dilution of the exhaust in either one or two steps to a temperature never greater than 125 °F (51.7 °C) at the primary sample filter. A backup filter provides a confirmation of sufficient filtering efficiency.

(9) Since various configurations can produce equivalent results, exact conformance with these drawings is not required. Additional components such as instruments, valves, solenoids, pumps, and switches may be used to provide additional information and coordinate the functions of the component systems. Other components, such as snubbers, which are not needed to maintain accuracy on some systems, may be excluded if their exclusion is based upon good engineering judgment.

(10) Other sampling and/or analytical systems may be used if shown to yield equivalent results and if approved in advance by the Administrator.

(b) *Component description.* The components necessary for exhaust sampling shall meet the following requirements:

(1) *Exhaust dilution system.* The PDP–CVS shall conform to all of the requirements listed for the exhaust gas PDP–CVS in § 86.1309(b). The CFV–CVS shall conform to all of the requirements listed for the exhaust gas CFV–CVS in § 86.1309(c). The EFC–CFV–CVS shall conform to all of the requirements listed for the exhaust gas EFC–CVS in § 86.1309(d). In addition, the CFV–CVS and EFC–CFV–CVS must conform to the following requirements:

(i) The flow capacity of the CVS must be sufficient to maintain the diluted exhaust stream at or below the temperatures required for the measurement of particulate and hydrocarbon emission noted below and at, or above, the temperatures where condensation

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of water in the exhaust gases could occur. This may be achieved by either of the following two methods:

(A) *Single-dilution method.* The flow capacity of the CVS must be sufficient to maintain the diluted exhaust stream at a temperature of 125 °F (51.7 °C) or less, at the sampling zone in the primary dilution tunnel and as required to prevent condensation at any point in the dilution tunnel. Direct sampling of the particulate material may then take place (Figure N90–5).

(B) *Double-dilution method.* The flow capacity of the CVS must be sufficient to maintain the diluted exhaust stream in the primary dilution tunnel at a temperature of 375 °F (191 °C) (250 °F (121 °C) for methanol fueled engines) or less at the sampling zone and as required to prevent condensation at any point in the dilution tunnel. Gaseous emission samples may be taken directly from this sampling point. An exhaust sample must then be taken at this point to be diluted a second time for use in determining particulate emissions. The secondary dilution system must provide sufficient secondary dilution air to maintain the double-diluted exhaust stream at a temperature of 125 °F (51.7 °C) or less immediately before the primary particulate filter in the secondary dilution tunnel.

(ii) For the CFV–CVS or EFC–CFV–CVS, either a heat exchanger or electronic flow compensation (which also includes the particulate sample flows) is required (see Figure N90–6).

(iii) For the CFV–CVS or EFC–CFV–CVS when a heat exchanger is used, the gas mixture temperature, measured at a point immediately ahead of the crit-

ical flow venturi, shall be within ±20 °F (±11 °C) of the average operating temperature observed during the test with the simultaneous requirement that condensation does not occur. The temperature measuring system (sensors and readout) shall have an accuracy and precision of ±3.4 °F (1.9 °C). For systems utilizing a flow compensator to maintain proportional sampling, the requirement for maintaining constant temperature is not necessary.

(iv) The primary dilution air and secondary dilution air (if applicable):

(A) Shall have a temperature of 77°±9 °F (25°±5 °C). For the first 10 seconds this specification is 77°±20 °F (25°±11 °C).

(B) May be filtered at the dilution air inlet.

(C) Primary dilution air may be sampled to determine background particulate levels, which can then be subtracted from the values measured in the diluted exhaust stream. The primary dilution air shall be sampled at the inlet to the primary dilution tunnel, if unfiltered, or downstream of any primary dilution air conditioning devices, if used.

(2) [Reserved]

(3) *Continuous HC measurement system.* (i) The continuous HC sample system (as shown in Figure N90–7 or N90–8) uses an ''overflow'' zero and span system. In this type of system, excess zero or span gas spills out of the probe when zero and span checks of the analyzer are made. The ''overflow'' system may also be used to calibrate the HC analyzer per §86.1321(b), although this is not required.

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(ii) No other analyzers may draw a sample from the continuous HC sample probe, line or system, unless a common sample pump is used for all analyzers and the sample line system design reflects good engineering practice.

(iii) The overflow gas flow rates into the sample line shall be at least 105 percent of the sample system flow rate.

(iv) The overflow gases shall enter the heated sample line as close as practicable to the outside surface of the CVS duct or dilution tunnel.

(v) The continuous HC sampling system shall consist of a probe (which must raise the sample to the specified temperature) and, where used, a sample transfer system (which must maintain

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the specified temperature). The continuous hydrocarbon sampling system (exclusive of the probe) shall:

(A) Maintain a wall temperature of 464K ± 11K (191°C ± 11°C) as measured at every separately controlled heated component (i.e., filters, heated line sections), using permanent thermocouples located at each of the separate components.

(B) Have a wall temperature of 464K ± 11K (191°C ± 11°C) over its entire length. The temperature of the system shall be demonstrated by profiling the thermal characteristics of the system at initial installation and after any major maintenance performed on the system. The temperature profile of the HC sampling system shall be demonstrated by inserting thermocouple wires (typically Teflon® coated for ease of insertion) into the sampling system assembled in-situ where possible, using good engineering judgement. The wire should be inserted up to the HFID inlet. Stabilize the sampling system heaters at normal operating temperatures. Withdraw the wires in increments of 5 cm to 10 cm (2 inches to 4 inches) including all fittings. Record the stabilized temperature at each position. The system temperature will be monitored during testing at the locations and temperature described in § 86.1310–90(b)(v)(A). Comment: It is understood that profiling of the sample line can be done under flowing conditions also as required with the probe.

(C) Maintain a gas temperature of 464K ±11K (191°C ±11°C) immediately before the heated filter and HFID. These gas temperatures will be determined by a temperature sensor located immediately upstream of each component.

(vi) The continuous hydrocarbon sampling probe shall:

(A) Be defined as the first 25.4 cm (10 in) to 76.2 cm (30 in) of the continuous hydrocarbon sampling system.

(B) Have a 0.483 cm (0.19 in) minimum inside diameter.

(C) Be installed in the primary dilution tunnel at a point where the dilution air and exhaust are well mixed (i.e., approximately 10 tunnel diameters downstream of the point where the exhaust enters the dilution tunnel).

(D) Be sufficiently distant (radially) from other probes and the tunnel wall so as to be free from the influence of any wakes or eddies.

(E) Increase the gas stream temperature to 464K ±11K (191°C ±11°C) by the exit of the probe. The ability of the probe to accomplish this shall be demonstrated at typical sample flow rates using the insertion thermocouple technique at initial installation and after any major maintenance. Compliance with the temperature specification shall be demonstrated by monitoring during each test the temperature of either the gas stream or the wall of the sample probe at its terminus.

(vii) The response time of the continuous measurement system shall be no greater than:

(A) 1.5 seconds from an instantaneous step change at the port entrance to the analyzer to within 90 percent of the step change.

(B) 20 seconds from an instantaneous step change at the entrance to the sample probe or overflow span gas port to within 90 percent of the step change. Analysis system response time shall be coordinated with CVS flow fluctuations and sampling time/test cycle offsets if necessary.

(C) For the purpose of verification of response times, the step change shall be at least 60 percent of full-scale chart deflection.

(4) *Primary-dilution tunnel.* (i) The primary dilution tunnel shall be:

(A) Small enough in diameter to cause turbulent flow (Reynolds Number greater than 4000) and of sufficient length to cause complete mixing of the exhaust and dilution air;

(B) At least 18 inches (46 cm) in diameter with a single-dilution system or at least 8 inches (20 cm) in diameter with a double-dilution system;

(C) Constructed of electrically conductive material which does not react with the exhaust components; and

(D) Electrically grounded.

(ii) The temperature of the diluted exhaust stream inside of the primary dilution tunnel shall be sufficient to prevent water condensation.

(iii) The engine exhaust shall be directed downstream at the point where it is introduced into the primary dilution tunnel.

(5) *Continuously integrated NOₓ, CO, and CO₂ measurement systems.* (i) The sample probe shall:

(A) Be in the same plane as the continuous HC probe, but shall be sufficiently distant (radially) from other probes and the tunnel wall so as to be free from the influences of any wakes or eddies.

(B) Heated and insulated over the entire length, to prevent water condensation, to a minimum temperature of 131 °F (55 °C). Sample gas temperature immediately before the first filter in the system shall be at least 131 °F (55 °C).

(ii) The continuous NO_X, CO, or CO_2 sampling and analysis system shall conform to the specifications of 40 CFR part 86, subpart D, with the following exceptions and revisions:

(A) The system components required to be heated by subpart D need only be heated to prevent water condensation, the minimum component temperature shall be 131 °F (55 °C).

(B) The system response defined in § 86.329–79 shall be no greater than 20 seconds. Analysis system response time shall be coordinated with CVS flow fluctuations and sampling time/test cycle offsets, if necessary.

(C) Alternative NO_X measurement techniques outlined in § 86.346–79 are not permitted for NO_X measurement in this subpart.

(D) All analytical gases shall conform to the specifications of § 86.1314.

(E) Any range on a linear analyzer below 155 ppm shall have and use a calibration curve conforming to § 86.330–79.

(F) The measurement accuracy requirements specified in § 86.338–79 are superseded by those specified in § 86.1338.

(iii) The chart deflections or voltage output of analyzers with non-linear calibration curves shall be converted to concentration values by the calibration curve(s) specified in subpart D (§ 86.330–79) before flow correction (if used) and subsequent integration takes place.

(6) *Particulate sampling system.* The particulate collection system must be configured in either of two ways. The single-dilution method collects a proportional sample from the primary tunnel, and then passes this sample through the collection filter. The double-dilution method collects a proportional sample from the primary tunnel, and then transfers this sample to a secondary dilution tunnel where the sample is further diluted; the double-diluted sample is then passed through the collection filter. Proportionality (i.e., mass flow ratio) between the primary tunnel flow rate and the sample flow rate must be maintained within ±5 percent. The requirements for these two systems are:

(i) *Single dilution method.* (A) The particulate sample probe shall be:

(*1*) Installed facing upstream at a point where the dilution air and exhaust air are well mixed (*i.e.,* on the primary tunnel centerline, approximately 10 tunnel diameters downstream of the point where the exhaust enters the primary dilution tunnel).

(*2*) Sufficiently distant (radially) from other sampling probes so as to be free from the influence of any wakes or eddies produced by the other probes.

(*3*) 0.5 in. (1.3 cm) minimum inside diameter.

(*4*) The distance from the sampling tip to the filter holder shall be at least 5 probe diameters for filters located inside the primary dilution tunnel, and not more than 40 inches (102 cm) for filters located outside the primary dilution tunnel.

(*5*) Designed to minimize the deposition of particulate in the probe (*i.e.,* bends should be as gradual as possible, protrusions (due to sensors, etc.) should be smooth and not sudden, etc.).

(B) The particulate sample pump(s) shall be located sufficiently distant from the dilution tunnel so that the inlet gas temperature is maintained at a constant temperature (±5 °F (±2.8 °C)) if flow compensation is not used.

(C) The gas meters or flow instrumentation shall be located sufficiently distant from the tunnel so that the inlet gas temperature remains constant (±5 °F (±2.8 °C)) if flow compensation is not used.

(D) Other sample flow handling and/or measurement systems may be used if shown to yield equivalent results and if approved in advance by the Administrator.

(ii) *Double-dilution method.* (A) The particulate sample transfer tube shall be configured and installed so that:

(*1*) The inlet faces upstream in the primary dilution tunnel at a point where the primary dilution air and exhaust are well mixed (*i.e.,* on the primary tunnel centerline, approximately 10 tunnel diameters downstream of the point where the exhaust enters the primary dilution tunnel).

(*2*) The particulate sample exits on the centerline of the secondary tunnel and points downstream.

(B) The particulate sample transfer tube shall be:

(*1*) Sufficiently distant (radially) from other sampling probes (in the primary dilution tunnel) so as to be free from the influence of any wakes or eddies produced by the other probes.

(*2*) 0.5 in (1.3 cm) minimum inside diameter.

(*3*) No longer than 36 in (91 cm) from inlet plane to exit plane.

(*4*) Designed to minimize the deposition of particulate during transfer (*i.e.,* bends should be as gradual as possible, protrusions (due to sensors, etc.) should be smooth and not sudden, etc.).

(*5*) Constructed of electrically conductive material which does not react with the exhaust components, and electrically grounded.

(C) The secondary dilution air shall be at a temperature of 77°±9 °F (25°±5 °C). For the first 10 seconds this specification is 77°±20 °F (25°±11 °C).

(D) The secondary-dilution tunnel shall be:

(*1*) 3.0 inches (7.6 cm) minimum inside diameter.

(*2*) Of sufficient length so as to provide a residence time of at least 0.25 seconds for the double-diluted sample.

(*3*) Constructed of electrically conductive material which does not react with the exhaust components, and electrically grounded.

(E) Additional dilution air must be provided so as to maintain a sample temperature of 125 °F (51.7 °C) or less immediately before the primary sample filter.

(F) The primary filter holder shall be located within 12.0 in (30.5 cm) of the exit of the secondary dilution tunnel.

(G) Other sample flow handling and/or measurement systems may be used if shown to yield equivalent results and if approved in advance by the Administrator.

(7) *Particulate sampling filters.* (i) Fluorocarbon-coated glass fiber filters or fluorocarbon-based (membrane) filters are required.

(ii) Particulate filters must have a minimum diameter of 70 mm (60 mm stain diameter). Larger diameter filters are acceptable.

(iii) The dilute exhaust will be simultaneously sampled by a pair of filters (one primary and one back-up filter) during the cold-start test and by a second pair of filters during the hot-start test. The back-up filter holder shall be located no more than 4 inches (10 cm) downstream of the primary filter holder. The primary and back-up filters shall not be in contact with each other.

(iv) It is recommended that the filter loading should be maximized consistent with other temperature requirements and the requirement to avoid moisture condensation. A filter pair loading of 1 mg is typically proportional to a 0.1 g/bhp-hr emission level. All particulate filters, reference filters, and background filters shall be handled in pairs during all weighing operations for emissions testing.

(8) *Methanol sampling system.* The methanol sampling system, shown in Figure N90–2, consists of impingers (or sample collection capsules) containing known volumes of deionized water and sampling pump to draw the proportional sample through the impingers.

(9) *Formaldehyde sampling system.* The formaldehyde sampling system, Figure N90–3, consists of sample collection impingers and sampling pump to draw the proportional sample through the impingers.

[54 FR 14578, Apr. 11, 1989, as amended at 59 FR 48525, Sept. 21, 1994; 60 FR 34370, June 30, 1995; 62 FR 47124, Sept. 5, 1997]

§ 86.1311–90 Exhaust gas analytical system; CVS bag sample.

(a) *Schematic drawings.* Figure N90–9 is a schematic drawing of the exhaust gas analytical system used for analyzing CVS bag samples from either Otto-cycle or diesel engines. Since various configurations can produce accurate results, exact conformance with the drawing is not required. Additional components such as instruments, valves, solenoids, pumps and switches

may be used to provide additional information and coordinate the functions of the component systems. Other components such as snubbers, which are not needed to maintain accuracy in some systems, may be excluded if their exclusion is based upon good engineering judgment.

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(b) *Major component description.* The analytical system, Figure N90–9, consists of a flame ionization detector (FID) (heated for methanol-fueled (235±15 °F (113±8 °C)) and for petroleum-

fueled diesel (375 °±10 °F (191 °±6 °C) engines) for the measurement of hydrocarbons, nondispersive infrared analyzers (NDIR) for the measurement of carbon monoxide and carbon dioxide, and a chemiluminescence analyzer (CL) for the measurement of oxides of nitrogen. The analytical system for methanol consists of a gas chromatograph (GC), equipped with a flame ionization detector. The analysis for formaldehyde is performed using high pressure liquid chromatography (HPLC) of 2,4-dinitrophenylhydrazine (DNPH) derivatives using ultraviolet (UV) detection. The exhaust gas analytical system shall conform to the following requirements:

(1) The CL requires that the nitrogen dioxide present in the sample be converted to nitric oxide before analysis. Other types of analyzers may be used if shown to yield equivalent results and if approved in advance by the Administrator.

(2) The carbon monoxide (NDIR) analyzer may require a sample conditioning column containing $CaSO_4$, or dessicating silica gel to remove water vapor, and containing ascarite to remove carbon dioxide from the CO analysis stream.

(i) If CO instruments are used which are essentially free of CO_2 and water vapor interference, the use of the conditioning column may be deleted. (*See* §§ 86.1322 and 86.1342.)

(ii) A CO instrument will be considered to be essentially free of CO_2 and water vapor interference if its response to a mixture of 3 percent CO_2 in N_2, which has been bubbled through water at room temperature, produces an equivalent CO response, as measured on the most sensitive CO range, which is less than 1 percent of full scale CO concentration on ranges above 300 ppm full scale or less than 3 ppm on ranges below 300 ppm full scale. (*See* § 86.1322.)

(c) *Alternate analytical systems.* Analysis systems meeting the specifications of 40 CFR part 86 subpart D may be used for testing required under this subpart, with the exception of §§ 86.346 and 86.347, provided that the subpart D systems meet the specifications of this subpart. Heated analyzers may be used in their heated configuration.

(d) *Other analyzers and equipment.* Other types of analyzers and equipment may be used if shown to yield equivalent results and if approved in advance by the Administrator.

[54 FR 14578, Apr. 11, 1989]

§ 86.1311–94 Exhaust gas analytical system; CVS bag sample.

(a) *Schematic drawings.* Figure N94–1 is a schematic drawing of the exhaust gas analytical system used for analyzing CVS bag samples from either Otto-cycle or diesel engines. Since various configurations can produce accurate results, exact conformance with the drawing is not required. Additional components such as instruments, valves, solenoids, pumps and switches may be used to provide additional information and coordinate the functions of the component systems. Other components such as snubbers, which are not needed to maintain accuracy in some systems, may be excluded if their exclusion is based upon good engineering judgment.

(b) *Major component description.* The analytical system, Figure N94–1, consists of a flame ionization detector (FID) (heated for methanol-fueled (235 ±15 °F (113 ±8 °C)) and for petroleum-fueled diesel (375 ±10 °F (191 ±6 °C) engines) for the measurement of hydrocarbons, a methane analyzer (consisting of a gas chromatograph combined with a FID) for the determination of CH_4 (for engines subject to NMHC standards, where applicable), nondispersive infrared analyzers (NDIR) for the measurement of carbon monoxide and carbon dioxide, and a chemiluminescence analyzer (CL) for the measurement of oxides of nitrogen. The analytical system for methanol consists of a gas chromatograph (GC), equipped with a flame ionization detector. The analysis for formaldehyde is performed using high pressure liquid chromatography (HPLC) of 2,4-dinitrophenylhydrazine (DNPH) derivatives using ultraviolet (UV) detection. The exhaust gas analytical system shall conform to the following requirements:

(1) The CL requires that the nitrogen dioxide present in the sample be converted to nitric oxide before analysis. Other types of analyzers may be used if shown to yield equivalent results and if

approved in advance by the Administrator.

(2) The carbon monoxide (NDIR) analyzer may require a sample conditioning column containing $CaSO_4$, or desiccating silica gel to remove water vapor, and containing ascarite to remove carbon dioxide from the CO analysis stream.

(i) If CO instruments are used which are essentially free of CO_2 and water vapor interference, the use of the conditioning column may be deleted (see §§ 86.1322 and 86.1342).

(ii) A CO instrument will be considered to be essentially free of CO_2 and water vapor interference if its response to a mixture of three percent CO_2 in N_2, which has been bubbled through water at room temperature, produces an equivalent CO response, as measured on the most sensitive CO range, which is less than one percent of full scale CO concentration on ranges above 300 ppm full scale or less than 3 ppm on ranges below 300 ppm full scale (see § 86.1322).

(3)(i) Using a methane analyzer consisting of a gas chromatograph combined with a FID, the measurement of methane shall be done in accordance with SAE Recommended Practice J1151, ''Methane Measurement Using Gas Chromatography.'' (Incorporated by reference pursuant to § 86.1(b)(2).)

(ii) For natural gas vehicles, the manufacturer has the option of using gas chromatography to measure NMHC through direct quantitation of individual hydrocarbon species. The manufacturer shall conform to standard industry practices and use good engineering judgement.

(c) *Alternate analytical systems.* Analysis systems meeting the specifications of subpart D of this part may be used for testing required under this subpart, with the exception of §§ 86.346 and 86.347, provided that the systems in subpart D of this part meet the specifications of this subpart. Heated analyzers may be used in their heated configuration.

(d) *Other analyzers and equipment.* Other types of analyzers and equipment may be used if shown to yield equivalent results and if approved in advance by the Administrator.

§ 86.1312–88 Weighing chamber and microgram balance specifications.

(a) *Ambient conditions.* (1) *Temperature.* The ambient temperature of the chamber (or room) in which the particulate filters are conditioned and weighed shall be maintained at 295 K ± 3 K (22 °C ± 3 °C) during all filter conditioning and weighing.

(2) *Humidity.* The humidity of the chamber (or room) in which the particulate filters are conditioned and weighed shall be maintained at a dew point temperature of 282.5 K ± 3 K (9.4 °C ± 3 °C) and a relative humidity of 45% ±8%. Either the dew point temperature or the relative humidity or both may be averaged over the preceding 10 minute period on a moving average basis.

(3) The chamber (or room) environment shall be free of any ambient contaminates (such as dust) that would settle on the particulate filters during their stabilization. It is required that at least two unused reference filter pairs remain in the weighing room at all times in covered (to reduce dust contamination) but unsealed (to permit humidity exchange) petri dishes. These reference filter pairs shall be placed in the same general area as the sample filters. These reference filter pairs shall be weighed within 4 hours of, but preferably at the same time as, the sample filter pair weighings.

(4) If the average weight of the reference filter pairs changes between sample filter weighings by more than 40 micrograms, then all sample filters and background filters in the process of stabilization shall be discarded and the emissions tests repeated.

(5) If the room (or chamber) environmental conditions are not met, then the filters shall remain in the conditioning room for at least one hour after correct conditions are met prior to weighing.

(6) The reference filter pairs shall be changed at least once a month, but never between clean and used

weighings of a given sample filter pairs. More than one set of reference filter pair may be used. The reference filters shall be the same size and material as the sample filters.

(b) *Weighing balance specifications.* The microgram balance used to determine the weights of all filters shall have a precision (standard deviation) of 20 micrograms and readability of 10 micrograms.

(Secs. 202, 203, 206, 207, 208, 301a, Clean Air Act, as amended; 42 U.S.C. 7521, 7522, 7525, 7541, 7542, 7601a)

[50 FR 10702, Mar. 15, 1985, as amended at 52 FR 47871, Dec. 16, 1987; 62 FR 47124, Sept. 5, 1997]

§ 86.1313–91 Fuel specifications.

(a) *Otto-cycle test fuel.* (1) Gasoline having the specifications listed in table N91–1 will be used by the Administrator in exhaust emission testing petroleum-fueled substantially equivalent specifications approved by the Administrator, shall be used by the manufacturer in exhaust emission testing, except that the octane specification does not apply.

TABLE N91–1

Item		ASTM	Value
Octane, research, min.	....	D2699 ..	93
Sensitivity, min	....	....	7.5
Lead (organic)	g/U.S. gal. (g/liter).	D3237 ..	[1] (0.050)
			[1] (0.013)
Distillation range:			
IBP	°F	D86	75–95
	(°C)	....	(23.9–35)
10 pct. point	°F	D86	120–135
	(°C)	....	(48.9–57.2)
50 pct. point	°F	D86	200–230
	(°C)	....	(93.3–110)
90 pct. point	°F	D86	300–325
	(°C)	....	(148.9–162.8)
EP	max. °F, ...	D86	415
	(°C)	....	(212.8)
Sulphur	max. wt. pct ...	D1266 ..	0.10
Phosphorus, max..	g/U.S. gal. (g/liter).	D3231 ..	0.005
			(0.0013)
RVP	psi, (kPa)	D323	8.0–9.2
			(60.0–63.4)
Hydrocarbon composition:			
Olefins	max. pct.	D1319 ..	10
Aromatics	max. pct.	D1319 ..	35
Saturates	....	D1319 ..	([2])

[1] Maximum.
[2] Remainder.

(2) Unleaded gasoline representative of commercial gasoline which will be generally available through retail outlets shall be used in service accumulation.

(i) The octane rating of the gasoline used shall be not higher than one Research octane number above the minimum recommended by the manufacturer and have a minimum sensitivity of 7.5 octane numbers, where sensitivity is defined as the Research octane number minus the Motor octane number.

(ii) The Reid Vapor Pressure of the gasoline used shall be characteristic of the motor fuel used during the season in which the service accumulation takes place.

(3) Methanol fuel used for exhaust and evaporative emission testing and in service accumulation of methanol-fueled Otto-cycle engines shall be representative of commercially available methanol fuel and shall consist of at least 50 percent methanol by volume.

(i) Manufacturers shall recommend the methanol fuel to be used for testing and service accumulation in accordance with paragraph (a)(3) of this section.

(ii) The Administrator shall determine the methanol fuel to be used for testing and service accumulation.

(4) Other methanol fuels may be used for testing and service accumulation provided:

(i) They are commercially available, and

(ii) Information, acceptable to the Administrator, is provided to show that only the designated fuel would be used in customer service, and

(iii) Use of a fuel listed under paragraph (a)(3) of this section would have a detrimental effect on emissions or durability, and

(iv) Written approval from the Administrator of the fuel specifications must be provided prior to the start of testing.

(5) The specification range of the fuels to be used under paragraphs (a)(2), (a)(3), and (a)(4) of this section shall be reported in accordance with § 86.090–21(b)(3).

(b) *Diesel Test fuel.* (1) The petroleum fuels for testing diesel engines employed for testing shall be clean and bright, with pour and cloud points adequate for operability. The petroleum

fuel may contain nonmetallic additives as follows: Cetane improver, metal deactivator, antioxidant, dehazer, antirust, pour depressant, dye, dispersant, and biocide. Except for the sulfur content of ''Type 2–D'' fuel, fuels specified for emissions testing are intended to be representative of commercially available in-use fuels.

(2) Petroleum fuel for diesel engines meeting the specifications in Table N91–2, or substantially equivalent specifications approved by the Administrator, shall be used in exhaust emissions testing. The grade of petroleum fuel used shall be commercially des-

ignated as ''Type 2–D'' grade diesel fuel except that fuel commercially designated as ''Type 1–D'' grade diesel fuel may be substituted provided that the manufacturer has submitted evidence to the Administrator demonstrating to the Administrator's satisfaction that this fuel will be the predominant in-use fuel. Such evidence could include such things as copies of signed contracts from customers indicating the intent to purchase and use ''Type 1–D'' grade diesel fuel as the primary fuel for use in the engines or other evidence acceptable to the Administrator.

TABLE N91–2

Item	ASTM	Type 1–D	Type 2–D
Cetane Number	D613	48–54	42–50
Cetane Index	D86	40–54	40–48
Distillation range:			
IBP °F	D86	330–390	340–400
(°C)		(165.6–198.9)	(171.1–204.4)
10 percent point, °F	D86	370–430	400–460
(°C)		(187.8–221.1)	(204.4–237.8)
50 percent point, °F	D86	410–480	470–540
(°C)		(210–248.9)	(243.3–282.2)
90 percent point, °F	D86	460–520	560–630
(°C)		(237.8–271.1)	(293.3–332.2)
EP, °F	D86	500–560	610–690
(°C)		(260.0–293.3)	(321.1–365.6)
Gravity, °API	D287	40–44	32–37
Total Sulfur, percent	D2622	0.08–0.12	0.08–0.12
Hydrocarbon composition:			
Aromatics, pct	D1319 or D5186	[1] 8	[1] 27
Paraffins, Naphthenes, Olefins	D1319	([2])	([2])
Flashpoint, °F	D93	120	130
(°C)		(48.9)	(54.4)
(minimum)			
Viscosity, Centistokes	D445	1.6–2.0	2.0–3.2

[1] Minimum.
[2] Remainder.

(3) Petroleum fuel for diesel engines meeting the specifications in table N91–3, or substantially equivalent specifications approved by the Administrator, shall be used in service accumulation. The grade of petroleum fuel used shall be commercially designated as ''Type 2–D'' grade diesel fuel except that fuel commercially designated as ''Type 1–D'' grade diesel fuel may be substituted provided that the manufac-

turer has submitted evidence to the Administrator demonstrating to the Administrator's satisfaction that this fuel will be the predominant in-use fuel. Such evidence could include such things as copies of signed contracts from customers indicating the intent to purchase and use ''Type 1–D'' grade diesel fuel as the primary fuel for use in the engines or other evidence acceptable to the Administrator.

TABLE N91–3

Item	ASTM	Type 1–D	Type 2–D
Cetane Number	D613	42–56	30–58
Distillation range:			
90 pct. point, °F	D86	440–530	540–630
(°C)		(226.7–276.7)	(282.2–332.2)

TABLE N91–3—Continued

Item	ASTM	Type 1–D	Type 2–D
Gravity, °API	D287	39–45	30–42
Total sulfur, pct.	D2622	0.08–0.12	0.08–0.12
Flashpoint, min., °F	D93	120	130
(°C)	....	(48.9)	(54.4)
Viscosity, centistokes	D455	1.2–2.2	1.5–4.5

(4) Methanol fuel used for exhaust and evaporative emission testing and in service accumulation of methanol-fueled diesel engines shall be representative of commercially available methanol fuel and shall consist of at least 50 percent methanol by volume.

(i) Manufacturers shall recommend the methanol fuel to be used for testing and service accumulation in accordance with paragraph (b)(4) of this section.

(ii) The Administrator shall determine the methanol fuel to be used for testing and service accumulation.

(5) Other fuels may be used for testing and service accumulation provided:

(i) They are commercially available, and

(ii) Information, acceptable to the Administrator, is provided to show that only the designated fuel would be used in customer service, and

(iii) Use of a fuel listed under paragraphs (b)(2) and (b)(3) or (b)(4) of this section would have a detrimental effect on emissions or durability, and

(iv) Written approval from the Administrator of the fuel specifications must be provided prior to the start of testing.

(6) The specification range of the fuels to be used under paragraphs (b)(2), (b)(3), (b)(4), and (b)(5) of this section shall be reported in accordance with § 86.090–21(b)(3).

(c) Fuels not meeting the specifications set forth in this section may be used only with the advance approval of the Administrator.

(d) *Mixtures of petroleum and methanol fuels for flexible fuel vehicles.* (1) Mixtures of petroleum and methanol fuels used for exhaust and evaporative emission testing and service accumulation for flexible fuel vehicles shall be within the range of fuel mixtures for which the vehicle was designed.

(2) Manufacturer testing and service accumulation may be performed using only those mixtures (mixtures may be different for exhaust testing, evaporative testing, and service accumulation) expected to result in the highest emissions, provided:

(i) The fuels which constitute the mixture will be used in customer service, and

(ii) Information, acceptable to the Administrator, is provided by the manufacturer to show that the designated fuel mixtures would result in the highest emissions, and

(iii) Written approval from the Administrator of the fuel specifications must be provided prior to the start of testing.

(3) The specification range of the fuels to be used under paragraph (d)(2) of this section shall be reported in accordance with § 86.090–21(b)(3).

[55 FR 34147, Aug. 21, 1990, as amended at 58 FR 21401, Apr. 21, 1993; 62 FR 47125, Sept. 5, 1997]

§ 86.1313–94 Fuel specifications.

(a) *Gasoline fuel.* (1) Gasoline having the specifications listed in table N94–1 will be used by the Administrator in exhaust emission testing. Gasoline having these specifications or substantially equivalent specifications approved by the Administrator, shall be used by the manufacturer in exhaust emission testing, except that the octane specification does not apply.

TABLE N94–1

Item	ASTM	Value
Octane, research, min	D2699	93
Sensitivity, min	....	7.5
Lead (organic), g/U.S. gal. (g/liter)	D3237	[1] (0.050) [1] (0.013)
Distillation range:		
IBP, °F (°C)	D86	75–95 (23.9–35)
10 pct. point, °F (°C)	D86	120–135 (48.9–57.2)
50 pct. point, °F (°C)	D86	200–230 (93.3–110)

TABLE N94–1—Continued

Item	ASTM	Value
90 pct. point, °F (°C)	D86	300–325 (148.9–162.8)
EP, max. °F (°C)	D86	415 (212.8)
Sulphur, Max., wt. pct	D1266	0.10
Phosphorus, max., g/U.S. gal. (g/liter)	D3231	0.005 (0.0013)
RVP, psi (kPa)	D323	8.0–9.2 (60.0–63.4)
Hydrocarbon composition:		
Olefins, max. pct	D1319	10
Aromatics, max. pct	D1319	35
Saturates	D1319	(2)

[1] Maximum.
[2] Remainder.

(2)(i) Unleaded gasoline representative of commercial gasoline which will be generally available through retail outlets shall be used in service accumulation.

(ii) The octane rating of the gasoline used shall not be higher than one Research octane number above the minimum recommended by the manufacturer and have a minimum sensitivity of 7.5 octane numbers, where sensitivity is defined as the Research octane number minus the Motor octane number.

(iii) The Reid Vapor Pressure of the gasoline used shall be characteristic of the motor fuel used during the season in which the service accumulation takes place.

(3) The specification range of the gasoline to be used under paragraph (a) of this section shall be reported in accordance with §86.094–21(b)(3).

(b) *Petroleum diesel test fuel.* (1) The petroleum fuels for testing diesel engines employed for testing shall be clean and bright, with pour and cloud points adequate for operability. The petroleum diesel fuel may contain non-metallic additives as follows: Cetane improver, metal deactivator, antioxidant, dehazer, antirust, pour depressant, dye, dispersant and biocide. Fuels specified for emissions testing are intended to be representative of commercially available in-use fuels.

(2) Petroleum fuel for diesel engines meeting the specifications in Table N94–2, or substantially equivalent specifications approved by the Administrator, shall be used in exhaust emissions testing. The grade of petroleum fuel used shall be commercially designated as ''Type 2–D'' grade diesel fuel except that fuel commercially designated at ''Type 1–D'' grade diesel fuel may be substituted provided that the manufacturer has submitted evidence to the Administrator demonstrating to the Administrator's satisfaction that this fuel will be the predominant in-use fuel. Such evidence could include such things as copies of signed contracts from customers indicating the intent to purchase and use ''Type 1–D'' grade diesel fuel as the primary fuel for use in the engines or other evidence acceptable to the Administrator.

TABLE N94–2

Item	ASTM	Type 1–D	Type 2–D
Cetane Number	D613	40–54	40–48
Cetane Index	D976	40–54	40–48
Distillation range:			
IBP °F	D86	330–390	340–400
(°C)		(165.6–198.9)	(171.1–204.4)
10 percent point, °F	D86	370–430	400–460
(°C)	(187.8–221.1)	(204.4–237.8)	
50 percent point, °F	D86	410–480	470–540
(°C)		(210–248.9)	(243.3–282.2)
90 percent point, °F	D86	460–520	560–630
(°C)		(237.8–271.1)	(293.3–332.2)
EP, °F	D86	500–560	610–690
(°C)		(260.0–293.3)	(321.1–365.6)
Gravity, °API	D287	40–44	32–37
Total Sulfur, percent	D2622	0.03–0.05	0.03–0.05
Hydrocarbon composition:			
Aromatics, pct	D1319 or D5186	[1] 8	[1] 27
Paraffins, Naphthenes, Olefins	D1319	(2)	(2)
Flashpoint, °F	D93	120	130
(°C)		(48.9)	(54.4)
(minimum)		....	....

TABLE N94–2—Continued

Item	ASTM	Type 1–D	Type 2–D
Viscosity, Centistokes	D445	1.6–2.0	2.0–3.2

[1] Minimum.
[2] Remainder.

(3) Petroleum diesel fuel for diesel engines meeting the specifications in table N94–3, or substantially equivalent specifications approved by the Administrator, shall be used in service accumulation. The grade of petroleum diesel fuel used shall be commercially designated as ''Type 2–D'' grade diesel fuel except that fuel commercially designated as ''Type 1–D'' grade diesel fuel may be substituted provided that the manufacturer has submitted evidence to the Administrator demonstrating to the Administrator's satisfaction that this fuel will be the predominant in-use fuel. Such evidence could include such things as copies of signed contracts from customers indicating the intent to purchase and use ''Type 1–D'' grade diesel fuel as the primary fuel for use in the engines or other evidence acceptable to the Administrator.

TABLE N94–3

Item	ASTM	Type 1–D	Type 2–D
Cetane Number	D613	40–56	30–58
Cetane Index	D976	Min. 40	Min. 40
Distillation range:			
90 pct. point °F (°C)	D86	440–530	540–630
		(226.7–276.7)	(282.2–332.2)
Gravity °API	D287	39–45	30–42
Total sulfur, min. pct	D2622	0.03–0.05	0.03–0.05
Flashpoint, min. °F (°C)	D93	120	130
		(48.9)	54.4
Viscosity, centistokes	D445	1.2–2.2	1.5–4.5

(4) Other petroleum distillate fuels may be used for testing and service accumulation provided:

(i) They are commercially available; and

(ii) Information, acceptable to the Administrator, is provided to show that only the designated fuel would be used in customer service; and

(iii) Use of a fuel listed under paragraphs (b)(2) and (b)(3) of this section would have a detrimental effect on emissions or durability; and

(iv) Written approval from the Administrator of the fuel specifications must be provided prior to the start of testing.

(5) The specification range of the fuels to be used under paragraph (b) of this section shall be reported in accordance with § 86.094–21(b)(3).

(c) *Methanol-fuel.* (1) Methanol fuel used for exhaust and evaporative emission testing and in service accumulation of methanol-fueled engines shall be representative of commercially available methanol fuel and shall consist of at least 50 percent methanol by volume.

(i) Manufacturers shall recommend the methanol fuel to be used for testing and service accumulation.

(ii) The Administrator shall determine the methanol fuel to be used for testing and service accumulation.

(2) Other methanol fuels may be used for testing and service accumulation provided:

(i) They are commercially available; and

(ii) Information, acceptable to the Administrator, is provided to show that only the designated fuel would be used in customer service; and

(iii) Use of a fuel listed under paragraph (b)(4)(c)(1) of this section would have a detrimental effect on emissions or durability; and

(iv) Written approval from the Administrator of the fuel specifications must be provided prior to the start of testing.

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(3) The specification range of the fuels to be used under paragraphs (c)(1) and (c)(2) of this section shall be reported in accordance with §86.094–21(b)(3).

(d) *Mixtures of petroleum and methanol fuels for flexible fuel vehicles.* (1) Mixtures of petroleum and methanol fuels used for exhaust emission testing and service accumulation for flexible fuel vehicles shall consist of the methanol and petroleum fuels listed in paragraph (a) or (b) of this section, and shall be within the range of fuel mixtures for which the vehicle was designed, as reported in accordance with §86.94–21. The Administrator may use any fuel mixture within this range for testing.

(2) The fuel mixtures used by the manufacturers shall be sufficient to demonstrate compliance over the full design range, and shall include:

(i) For emission testing:

(A) A petroleum fuel specified in paragraph (a) or paragraph (b) of this section;

(B) A methanol fuel representative of the methanol fuel expected to the found in use.

(ii) For service accumulation, an alternating combination of the fuels specified in paragraphs (a) or (b), and (c) of this section that, based on good engineering judgement, demonstrates the durability of the emissions control system. The combination shall be selected such that the cumulative volumes of both the methanol fuel and the petroleum fuel used shall be at least 25 percent of the total fuel volume. The fuels shall be or alternated at intervals not to exceed 500 hours.

(iii) Or, other combinations for testing and/or service accumulation which demonstrate compliance with the standards over the entire design range of the vehicle, provided that written approval is obtained from the Administrator prior to the start of testing.

(3) The specification range of the fuels to be used under this paragraph (d) shall be reported in accordance with §86.094–21.

(e) *Natural gas-fuel.* (1) Natural gas-fuel having the following specifications will be used by the Administrator for exhaust and evaporative emission testing of natural gas-fueled engines:

NATURAL GAS CERTIFICATION FUEL SPECIFICATIONS

Item		ASTM test method No.	Value
Methane	min. mole pct.	D1945	89.0
Ethane	max. mole pct.	D1945	4.5
C_3 and higher	max. mole pct.	D1945	2.3
C_6 and higher	max. mole pct.	D1945	0.2
Oxygen	max. mole pct.	D1945	0.6
Inert gases:			
Sum of CO_2 and N_2	max. mole pct.	D1945	4.0
Odorant [1]			

[1] The natural gas at ambient conditions must have a distinctive odor potent enough for its presence to be detected down to a concentration in air of not over 1/5 (one-fifth) of the lower limit of flammability.

(2) Natural gas-fuel representative of commercial natural gas-fuel and which will be generally available through retail outlets shall be used in service accumulation.

(3) Other natural gas-fuels may be used for testing and service accumulation provided:

(i) They are commercially available;

(ii) Information, acceptable to the Administrator, is provided to show that only the designated fuel would be used in customer service; and

(iii) Written approval from the Administrator of the fuel specifications must be provided prior to the start of testing.

(4) The specification range of the fuels to be used under paragraphs (e)(1) and (e)(2) of this section shall be reported in accordance with §86.094–21(b)(3).

(f) *Liquified petroleum gas-fuel.* (1) Liquified petroleum gas-fuel used for exhaust and evaporative emission testing and in service accumulation shall be commercially available liquefied petroleum gas-fuel.

(i) Manufacturers shall recommend the liquefied petroleum gas-fuel to be used for testing and service accumulation.

(ii) The Administrator shall determine the liquefied petroleum gas-fuel to be used for testing and service accumulation.

(2) Other liquefied petroleum gas-fuels may be used for testing and service accumulation provided:

(i) They are commercially available;

(ii) Information, acceptable to the Administrator, is provided to show

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that only the designated fuel would be used in customer service; and

(iii) Written approval from the Administrator of the fuel specifications must be provided prior to the start of testing.

(3) The specification range of the fuels to be used under paragraphs (f)(1) and (f)(2) of this section shall be measured in accordance with ASTM D2163–91 and reported in accordance with § 86.094–21(b)(3).

(g) Fuels not meeting the specifications set forth in this section may be used only with the advance approval of the Administrator.

[59 FR 48528, Sept. 21, 1994, as amended at 60 FR 34371, June 30, 1995; 62 FR 47125, Sept. 5, 1997]

§ 86.1313–98 Fuel specifications.

Section 86.1313–98 includes text that specifies requirements that differ from § 86.1313–94. Where a paragraph in § 86.1313–94 is identical and applicable to § 86.1313–98, this may be indicated by specifying the corresponding paragraph and the statement ''[Reserved]. For guidance see § 86.1313–94''.

(a) through (b)(1) [Reserved]. For guidance see § 86.1313–94.

(b)(2) Petroleum fuel for diesel engines meeting the specifications in Table N98–2, or substantially equivalent specifications approved by the Administrator, shall be used in exhaust emissions testing. The grade of petroleum fuel used shall be commercially designated as ''Type 2–D'' grade diesel fuel except that fuel commercially designated at ''Type 1–D'' grade diesel fuel may be substituted provided that the manufacturer has submitted evidence to the Administrator demonstrating to the Administrator's satisfaction that this fuel will be the predominant in-use fuel. Such evidence could include such things as copies of signed contracts from customers indicating the intent to purchase and use ''Type 1–D'' grade diesel fuel as the primary fuel for use in the engines or other evidence acceptable to the Administrator.

TABLE N98–2

Item	ASTM	Type 1–D	Type 2–D
Cetane Number	D613	40–54	40–48
Cetane Index	D976	40–54	40–48
Distillation range:			
IBP °F	D86	330–390	340–400
(°C)		(165.6–198.9)	(171.1–204.4)
10 percent point, °F	D86	370–430	400–460
(°C)		(187.8–221.1)	(204.4–237.8)
50 percent point, °F	D86	410–480	470–540
(°C)		(210–248.9)	(243.3–282.2)
90 percent point, °F	D86	460–520	560–630
(°C)		(237.8–271.1)	(293.3–332.2)
EP, °F	D86	500–560	610–690
(°C)		(260.0–293.3)	(321.1–365.6)
Gravity, °API	D287	40–44	32–37
Total Sulfur, percent	D2622	0.03–0.05	0.03–0.05
Hydrocarbon composition:			
Aromatics, pct	D5186	[1] 8	[1] 27
Paraffins, Naphthenes, Olefins	D1319	([2])	([2])
Flashpoint, °F	D93	120	130
(°C)		(48.9)	(54.4)
(minimum)		....	....
Viscosity, Centistokes	D445	1.6–2.0	2.0–3.2

[1] Minimum.
[2] Remainder.

(b)(3) through (e) [Reserved]. For guidance see § 86.1313–94.

[62 FR 47126, Sept. 5, 1997]

§ 86.1314–84 Analytical gases.

(a) Gases for the CO and CO_2 analyzers shall be single blends of CO and CO_2, respectively, using nitrogen as the diluent.

(b) Gases for the hydrocarbon analyzer shall be single blends of propane using air as the diluent.

(c) Gases for the NO_X analyzer shall be single blends of NO named as NO_X with a maximum NO_2 concentration of 5 percent of the nominal value using nitrogen as the diluent.

(d) Fuel for the FID shall be a blend of 40±2 percent hydrogen with the balance being helium. The mixture shall contain less than 1 ppm equivalent carbon response; 98 to 100 percent hydrogen fuel may be used with advance approval of the Administrator.

(e) The allowable zero gas (air or nitrogen) impurity concentrations shall not exceed 1 ppm equivalent carbon response, 1 ppm carbon monoxide, 0.04 percent (400 ppm) carbon dioxide and 0.1 ppm nitric oxide.

(f)(1) ''Zero-grade air'' includes artificial ''air'' consisting of a blend of nitrogen and oxygen with oxygen concentrations between 18 and 21 mole percent.

(2) Calibration gases shall be accurate to within ±1 percent of NBS gas standards, or other gas standards which have been approved by the Administrator.

(3) Span gases shall be accurate to within ±2 percent of NBS gas standards, or other gas standards which have been approved by the Administrator.

(g) The use of precision blending devices (gas dividers) to obtain the required calibration gas concentrations is acceptable, provided that the blended gases are accurate to within ±1.5 percent of NBS gas standards, or other gas standards which have been approved by the Administrator. This accuracy implies that primary gases used for blending must be ''named'' to an accuracy of at least ±1 percent, traceable to NBS or other approved gas standards.

[48 FR 52210, Nov. 16, 1983, as amended at 49 FR 48144, Dec. 10, 1984]

§ 86.1314–94 Analytical gases.

(a) Gases for the CO and CO_2 analyzers shall be single blends of CO and CO_2, respectively, using nitrogen as the diluent.

(b) Gases for the hydrocarbon analyzer shall be:

(1) Single blends of propane using air as the diluent; and

(2) Optionally, for response factor determination, single blends of methanol using air as the diluent.

(c) Gases for the methane analyzer shall be single blends of methane using air as the diluent.

(d) Gases for the NO_X analyzer shall be single blends of NO named as NO_X with a maximum NO_2 concentration of five percent of the nominal value using nitrogen as the diluent.

(e) Fuel for FIDs and HFIDs and methane analyzers shall be a blend of 40 ±2 percent hydrogen with the balance being helium. The mixture shall contain less than 1 ppm equivalent carbon response. 98 to 100 percent hydrogen fuel may be used with advance approval by the Administrator.

(f) The allowable zero gas (air or nitrogen) impurity concentrations shall not exceed 1 ppm equivalent carbon response, 1 ppm carbon monoxide, 0.04 percent (400 ppm) carbon dioxide and 0.1 ppm nitric oxide.

(g)(1) ''Zero-grade air'' includes artificial ''air'' consisting of a blend of nitrogen and oxygen with oxygen concentrations between 18 and 21 mole percent.

(2) Calibration gases (not including methanol) shall be traceable to within one percent of NIST (formerly NBS) gas standards, or other gas standards which have been approved by the Administrator.

(3) Span gases (not including methanol) shall be accurate to within two percent of true concentration, where true concentration refers to NIST (formerly NBS) gas standards, or other gas standards which have been approved by the Administrator.

(4) Methanol in air gases used for response factor determination shall:

(i) Be traceable to within ±2 percent of NIST (formerly NBS) gas standards, or other standards which have been approved by the Administrator; and

(ii) Remain within ±2 percent of the labeled concentration. Demonstration of stability shall be based on a quarterly measurement procedure with a precision of ±2 percent (two standard deviations), or other method approved

by the Administrator. The measurement procedure may incorporate multiple measurements. If the true concentration of the gas changes by more than two percent, but less than ten percent, the gas may be relabeled with the new concentration.

(h) The use of precision blending devices (gas dividers) to obtain the required calibration gas concentrations is acceptable, provided that the blended gases are accurate to within ±1.5 percent of NBS gas standards, or other gas standards which have been approved by the Administrator. This accuracy implies that primary gases used for blending must be ''named'' to an accuracy of at least ±1 percent, traceable to NBS or other approved gas standards.

[59 FR 48530, Sept. 21, 1994, as amended at 60 FR 34371, June 30, 1995]

§ 86.1316–90 Calibrations; frequency and overview.

(a) Calibrations shall be performed as specified in §§ 86.1318 through 86.1326.

(b) At least monthly or after any maintenance which could alter calibration, the following calibrations and checks shall be performed:

(1) Calibrate the hydrocarbon analyzer, carbon dioxide analyzer, carbon monoxide analyzer, oxides of nitrogen analyzer, methanol analyzer and formaldehyde analyzer (certain analyzers may require more frequent calibration depending on the equipment and use). New calibration curves need not be generated each month if the existing curve meets the requirements of §§ 86.1321 through 86.1324.

(2) Calibrate the engine dynamometer flywheel torque and speed measurement transducers, and calculate the feedback signals to the cycle verification equipment.

(3) Check the oxides of nitrogen converter efficiency.

(c) At least weekly or after any maintenance which could alter calibration, the following checks shall be performed:

(1) [Reserved]

(2) Perform a CVS system verification.

(3) Check the shaft torque feedback signal at steady-state conditions by comparing:

(i) Shaft torque feedback to dynamometer beam load, or

(ii) By comparing in-line torque to armature current, or

(iii) By checking the in-line torque meter with a dead weight per § 86.1308(e).

(d) The CVS positive displacement pump or critical flow venturi shall be calibrated following initial installation, major maintenance or as necessary when indicated by the CVS system verification (described in § 86.1319).

(e) Sample conditioning columns, if used in the CO analyzer train, should be checked at a frequency consistent with observed column life or when the indicator of the column packing begins to show deterioration.

(f) *For diesel fuel testing only.* The carbon monoxide analyzer shall be calibrated at least every two months or after any maintenance which could alter calibration.

[54 FR 14591, Apr. 11, 1989, as amended at 58 FR 58426, Nov. 1, 1993; 62 FR 47126, Sept. 5, 1997]

§ 86.1316–94 Calibrations; frequency and overview.

(a) Calibrations shall be performed as specified in §§ 86.1318 through 86.1326.

(b) At least monthly or after any maintenance which could alter calibration, the following calibrations and checks shall be performed:

(1) Calibrate the hydrocarbon analyzer, carbon dioxide analyzer, carbon monoxide analyzer, and oxides of nitrogen analyzer (certain analyzers may require more frequent calibration depending on the equipment and use). New calibration curves need not be generated each month if the existing curve meets the requirements of §§ 86.1321 through 86.1324.

(2) Calibrate the engine dynamometer flywheel torque and speed measurement transducers, and calculate the feedback signals to the cycle verification equipment.

(3) Check the oxides of nitrogen converter efficiency.

(c) At least weekly or after any maintenance which could alter calibration, the following checks shall be performed:

(1) Perform a CVS system verification.

(2) Check the shaft torque feedback signal at steady-state conditions by comparing:

(i) Shaft torque feedback to dynamometer beam load; or

(ii) By comparing in-line torque to armature current; or

(iii) By checking the in-line torque meter with a dead weight per § 86.1308(e).

(d) The CVS positive displacement pump or critical flow venturi shall be calibrated following initial installation, major maintenance or as necessary when indicated by the CVS system verification (described in § 86.1319).

(e) Sample conditioning columns, if used in the CO analyzer train, should be checked at a frequency consistent with observed column life or when the indicator of the column packing begins to show deterioration.

(f) For diesel fuel testing only. The carbon monoxide analyzer shall be calibrated at least every two months or after any maintenance which could alter calibration.

[59 FR 48530, Sept. 21, 1994, as amended at 60 FR 34371, June 30, 1995; 62 FR 47126, Sept. 5, 1997]

§ 86.1318–84 Engine dynamometer system calibrations.

(a) The engine flywheel torque and engine speed measurement transducers shall be calibrated at least once each month with the calibration equipment described in § 86.1308–84.

(b) The engine flywheel torque feedback signals to the cycle verification equipment shall be electronically checked before each test, and adjusted as necessary.

(c) Other engine dynamometer system calibrations shall be performed as dictated by good engineering practice.

(d) When calibrating the engine flywheel torque transducer, any lever arm used to convert a weight or a force through a distance into a torque shall be used in a horizontal position (±5 degrees).

(e) Calibrated resistors may not be used for engine flywheel torque transducer calibration, but may be used to span the transducer prior to engine testing.

§ 86.1319–84 CVS calibration.

(a) The CVS is calibrated using an accurate flowmeter and restrictor valve. The flowmeter calibration shall be traceable to the NBS, and will serve as the reference value (NBS ''true'' value) for the CVS calibration. (Note: In no case should an upstream screen or other restriction which can affect the flow be used ahead of the flowmeter unless calibrated throughout the flow range with such a device.) The CVS calibration procedures are designed for use of a ''metering venturi'' type flowmeter. Large radius or ASME flow nozzles are considered equivalent if traceable to NBS measurements. Other measurement systems may be used if shown to be equivalent under the test conditions in this action and traceable to NBS measurements. Measurements of the various flowmeter parameters are recorded and related to flow through the CVS. Procedures used by EPA for both PDP– and CFV–CVS's are outlined below. Other procedures yielding equivalent results may be used if approved in advance by the Administrator.

(b) After the calibration curve has been obtained, verification of the entire system may be performed by injecting a known mass of gas into the system and comparing the mass indicated by the system to the true mass injected. An indicated error does not necessarily mean that the calibration is wrong, since other factors can influence the accuracy of the system (e.g., analyzer calibration, leaks, or HC hangup). A verification procedure is found in paragraph (e) of this section.

(c) *PDP calibration.* (1) The following calibration procedure outlines the equipment, the test configuration, and the various parameters which must be measured to establish the flow rate of the CVS pump.

(i) All the parameters related to the pump are simultaneously measured with the parameters related to a flowmeter which is connected in series with the pump.

(ii) The calculated flow rate, ft³/min. (at a pump inlet absolute pressure and temperature), can then be plotted versus a correlation function which is the value of a specific combination of pump parameters.

(iii) The linear equation which relates the pump flow and the correlation function is then determined.

(iv) In the event that a CVS has a multiple speed drive, a calibration for each range used must be performed.

(2) This calibration procedure is based on the measurement of the absolute values of the pump and flowmeter parameters that relate the flow rate at each point. Two conditions must be maintained to assure the accuracy and integrity of the calibration curve:

(i) The temperature stability must be maintained during calibration. (Flowmeters are sensitive to inlet temperature oscillations; this can cause the data points to be scattered. Gradual changes in temperature are acceptable as long as they occur over a period of several minutes.)

(ii) All connections and ducting between the flowmeter and the CVS pump must be absolutely void of leakage.

(3) During an exhaust emission test the measurement of these same pump parameters enables the user to calculate the flow rate from the calibration equation.

(4) Connect a system as shown in Figure N84–6. Although particular types of equipment are shown, other configurations that yield equivalent results may be used if approved in advance by the Administrator. For the system indicated, the following measurements and accuracies are required:

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CALIBRATION DATA MEASUREMENTS

Parameter	Symbol	Units	Sensor-readout tolerances
Barometric pressure (corrected)	P_B	In. Hg (kPa)	±.10 in. Hg (±.340 kPa).
Ambient temperature	T_A	°F (°C)	±.5 °F (±.28 °C).
Air temperature into metering venturi	ETI	°F (°C)	±2.0 °F (±1.11 °C).
Pressure drop between the inlet and throat of metering venturi.	EDP	In. H2O (kPa)	±.05 in. H_2O (±.012 kPa).
Air flow	Q_S	Ft³/min. (m³/min.)	±5% of NBS "true" value.
Air temperature at CVS pump inlet	PTI	°F (°C)	±2.0 °F (±1.11 °C).
Pressure depression at CVS pump inlet	PPI	In. Fluid (kPa)	±.13 in. Fluid (±.055 kPa).
Specific gravity of manometer fluid (1.75 oil)	Sp. G		
Pressure head at CVS pump outlet	PPO	In. Fluid (kPa)	±.13 in. Fluid (±.055 kPa).
Air temperature at CVS pump outlet (optional)	PTO	°F (°C)	±2.0 °F (±1.11 °C).
Pump revolutions during test period	N	Revs	±1 Rev.
Elapsed time for test period	t	s	±.5 s.

(5) After the system has been connected as shown in Figure N84–6, set the variable restrictor in the wide open position and run the CVS pump for 20 minutes. Record the calibration data.

(6) Reset the restrictor valve to a more restricted condition in an increment of pump inlet depression that will yield a minimum of six data points for the total calibration. Allow the system to stabilize for 3 minutes and repeat the data acquisition.

(7) *Data analysis:* (i) The air flow rate, Q_s, at each test point is calculated in standard cubic feet per minute (68 °F, 29.92″ Hg) from the flowmeter data using the manufacturer's prescribed method.

(ii) The air flow rate is then converted to pump flow, V_o, in cubic feet per revolution at absolute pump inlet temperature and pressure:

ER06OC93.204

Where:
V_o=Pump flow, ft³/revolution (m³/revolution) at T_p, P_p
Q_s=Meter air flow rate in standard cubic feet per minute, standard conditions are 68 °F, 29.92 inches Hg (20 °C, 101.3 kPa)
n=Pump speed in revolutions per minute
T_p=Pump inlet temperature °R(°K)
=PTI + 460 (°R), or
=PTI + 273 (°K)
P_p=Absolute pump inlet pressure, inches Hg (kPa)
=P_B − PPI (Sp. Gr./13.5955) and
=P_B − PPI for SI units
Where:
P_B=barometric pressure, inches Hg (kPa)
PPI=Pump inlet depression, inches fluid (kPa)
Sp. Gr.=Specific gravity of manometer fluid

(iii) The correlation function at each test point is then calculated from the calibration data.

ER06OC93.205

Where:
X_o = correlation function.
ΔP = The pressure differential from pump inlet to pump outlet, inches Hg (kPa).
= P_e − P_p
P_e = Absolute pump outlet pressure, inches Hg (kPa)
= P_B + PPO(Sp. Gr./13.5955) and

= P_B for SI units

Where:

PPO = Pressure head at pump outlet, inches fluid (kPa).

(iv) A linear least squares fit is performed to generate the calibration equation which has the form:

V_o=D_o − M(X_o)

D_o and M are the intercept and slope constants, respectively, describing the regression lines.

(8) A CVS system that has multiple speeds should be calibrated on each speed used. The calibration curves generated for the ranges will be approximately parallel and the intercept values, D_o, will increase as the pump flow range decreases.

(9) If the calibration has been performed carefully, the calculated values from the equation will be within ±0.50 percent of the measured value of V_o. Values of M will vary from one pump to another, but values of D_o for pumps of the same make, model and range should agree within ±3 percent of each other. Particulate influx over time will cause the pump slip to decrease, as reflected by lower values for M. Calibrations should be performed at pump start-up and after major maintenance to assure the stability of the pump slip rate. Analysis of mass injection data will also reflect pump slip stability.

(d) *CFV calibration.* (1) Calibration of the CFV is based upon the flow equation for a critical venturi. Gas flow is a function of inlet pressure and temperature:

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The calibration procedure described in paragraph (d)(3) of this section establishes the value of the calibration coefficient at measured values of pressure, temperature and air flow.

(2) The manufacturer's recommended procedure shall be followed for calibrating electronic portions of the CFV.

(3) Measurements necessary for flow calibration are as follows:

CALIBRATION DATA MEASUREMENTS

Parameter	Symbol	Units	Tolerances
Barometric pressure (corrected)	P_b	Inches Hg (kPa)	± .01 in Hg (±.034 kPa).
Air temperature, flowmeter	ETI	°F (°C)	±.25°F (±.14°C).
Pressure depression upstream of LFE	EPI	Inches H2O (kPa)	±.05 in H_2O (±.012 kPa).
Pressure drop across LFE matrix	EDP	Inches H2O (kPa)	±.005 in H_2O (±.001 kPa).
Air flow	Q_s	F³/min. (m³/min.)	±.5 pct.
CFV inlet depression	PPI	Inches fluid (kPa)	±.13 in fluid (±.055 kPa).
Temperature at venturi inlet	T_v	°F (°C)	±0.5°F (±0.28°C).
Specific gravity of manometer fluid (1.75 oil)	Sp. Gr		

(4) Set up equipment as shown in Figure N84–7 and eliminate leaks. (Leaks between the flow measuring devices and the critical flow venturi will seriously affect the accuracy of the calibration.)

(5) Set the variable flow restrictor to the open position, start the blower, and allow the system to stabilize. Record data from all instruments.

(6) Vary the flow restrictor and make at least eight readings across the critical flow range of the venturi.

(7) *Data analysis.* The data recorded during the calibration are to be used in the following calculations:

(i) The air flow rate, Qs, at each test point is calculated in standard cubic feet per minute from the flow meter data using the manufacturer's prescribed method.

(ii) Calculate values of the calibration coefficient for each test point:

ER06OC93.207

(iii) Plot K_v as a function of venturi inlet pressure. For choked flow, K_v will have a relatively constant value. As pressure decreases (vacuum increases), the venturi becomes unchoked and K_v decreases. (See Figure N84–8.)

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(iv) For a minimum of 8 points in the critical region calculate an average K_v and the standard deviation.

(v) If the standard deviation exceeds 0.3 percent of the average K_v, take corrective action.

(e) *CVS system verification.* The following ''gravimetric'' technique can be used to verify that the CVS and analytical instruments can accurately measure a mass of gas that has been injected into the system. (Verification can also be accomplished by constant flow metering using critical flow orifice devices.)

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(1) Obtain a small cylinder that has been charged with pure propane.

(2) Determine the weight of the reference propane cylinder to an accuracy of ±0.2 percent or less of the actual amount of propane discharged into the system.

(3) Operate the CVS in the normal manner and release a quantity of pure propane into the system during the sampling period (approximately 5 minutes).

(4) The calculations of §86.1342 are performed in the normal way except in the case of propane. The density of propane (17.30 g/ft³/carbon atom (0.6109 kg/m³/carbon atom)) is used in place of the density of exhaust hydrocarbons.

(5) The gravimetric mass is subtracted from the CVS measured mass and then divided by the gravimetric mass to determine the percent accuracy of the system.

(6) Good engineering practice requires that the cause for any discrepancy greater than ± 2 percent must be found and corrected.

[48 FR 52210, Nov. 16, 1983, as amended at 49 FR 48144, Dec. 10, 1984; 52 FR 47871, Dec. 16, 1987; 63 FR 24449, May 4, 1998]

§ 86.1319–90 CVS calibration.

(a) The CVS is calibrated using an accurate flowmeter and restrictor valve. The flowmeter calibration shall be traceable to the NBS, and will serve as the reference value (NBS ''true'' value) for the CVS calibration. (*Note:* In no case should an upstream screen or other restriction which can affect the flow be used ahead of the flowmeter unless calibrated throughout the flow range with such a device.) The CVS calibration procedures are designed for use of a ''metering venturi'' type flowmeter. Large radius or ASME flow nozzles are considered equivalent if traceable to NBS measurements. Other measurement systems may be used if shown to be equivalent under the test conditions in this section and traceable to NBS measurements. Measurements of the various flowmeter parameters are recorded and related to flow through the CVS. Procedures used by EPA for both PDP–CVS and CFV–CVS are outlined below. Other procedures yielding equivalent results may be used

if approved in advance by the Administrator.

(b) After the calibration curve has been obtained, verification of the entire system may be performed by injecting a known mass of gas into the system and comparing the mass indicated by the system to the true mass injected. An indicated error does not necessarily mean that the calibration is wrong, since other factors can influence the accuracy of the system (*e.g.,* analyzer calibration, leaks, or HC hangup). A verification procedure is found in paragraph (e) of this section.

(c) *PDP calibration.* (1) The following calibration procedure outlines the equipment, the test configuration, and the various parameters which must be measured to establish the flow rate of the CVS pump.

(i) All the parameters related to the pump are simultaneously measured with the parameters related to a flowmeter which is connected in series with the pump.

(ii) The calculated flow rate, ft³/min, (at pump inlet absolute pressure and temperature) can then be plotted versus a correlation function which is the value of a specific combination of pump parameters.

(iii) The linear equation which relates the pump flow and the correlation function is then determined.

(iv) In the event that a CVS has a multiple speed drive, a calibration for each range used must be performed.

(2) This calibration procedure is based on the measurement of the absolute values of the pump and flowmeter parameters that relate the flow rate at each point. Two conditions must be maintained to assure the accuracy and integrity of the calibration curve:

(i) The temperature stability must be maintained during calibration. (Flowmeters are sensitive to inlet temperature oscillations; this can cause the data points to be scattered. Gradual changes in temperature are acceptable as long as they occur over a period of several minutes.)

(ii) All connections and ducting between the flowmeter and the CVS pump must be absolutely void of leakage.

(3) During an exhaust emission test the measurement of these same pump

parameters enables the user to calculate the flow rate from the calibration equation.

(4) Connect a system as shown in Figure N84–6. Although particular types of equipment are shown, other configurations that yield equivalent results may be used if approved in advance by the Administrator. For the system indicated, the following measurements and accuracies are required:

CALIBRATION DATA MEASUREMENTS

Parameter	Symbol	Units	Sensor-readout tolerances
Barometric pressure (corrected)	P_B	in. Hg (kPa)	±0.10 in. Hg (±0.340 kPa).
Ambient temperature	T_A	°F (°C)	±0.5 °F (±0.28 °C).
Air temperature into metering venturi	ETI	°F (°C)	±2.0 °F (±1.1 °C).
Pressure drop between the inlet and throat of metering venturi.	EDP	in. H_2O (kPa)	±0.05 in H_2O (±0.012 kPa).
Air flow	Q_s	ft³/min (m³/min) ...	±0.5% of NBS "true" value.
Air temperature at CVS pump inlet	PTI	°F (°C)	±2.0 °F (±1.1 °C).
Pressure depression at CVS pump inlet	PPI	in. Fluid (kPa)	±0.13 in. Fluid (±0.055 kPa).
Specific gravity of manometer fluid (1.75 oil)	Sp.Gr.	....	.
Pressure head at CVS pump outlet	PPO	in. Fluid (kPa)	±0.13 in. Fluid (±0.055 kPa).
Air temperature at CVS pump outlet (optional)	PTO	°F (°C)	±2.0 °F (±1.1 °C).
Pump revolutions during test period	N	Revs	± 1 Rev..
Elapsed time for test period	t	sec.	±0.5 sec.

(5) After the system has been connected as shown in Figure N84–6, set the variable restrictor in the wide open position and run the CVS pump for 20 minutes. Record the calibration data.

(6) Reset the restrictor valve to a more restricted condition in an increment of pump inlet depression that will yield a minimum of six data points for the total calibration. Allow the system to stabilize for 3 minutes and repeat the data acquisition.

(7) *Data analysis:*

(i) The air flow rate, Q_s, at each test point is calculated in standard cubic feet per minute (68°, 29.92 in. Hg.) from the flowmeter data using the manufacturer's prescribed method.

(ii) The air flow rate is then converted to pump flow, V_o, in cubic feet per revolution at absolute pump inlet temperature and pressure:

$$V_o = (Q_{s/n}) \times (T_p/528) \times (29.92/P_p)$$

Where:

(A) V_o = Pump flow, ft³/rev (m³/rev) at T_p, P_p.

(B) Q_s = Meter air flow rate in standard cubic feet per minute, standard conditions are 68 °F, 29.92 in. Hg (20 °C, 101.3 kPa).

(C) n = Pump speed in revolutions per minute.

(D) T_p = Pump inlet temperature °R(°K) = PTI + 460 (°R), or = PTI + 273 (°K).

(E) P_p = Absolute pump inlet pressure, in. Hg. (kPa)

= P_B − PPI(Sp.Gr./13.5955) and

= PB − PPI for SI units.

Where:

(F) P_B = barometric pressure, in. Hg. (kPa).

(G) PPI = Pump inlet depression, in. fluid (kPa).

(H) Sp.Gr. = Specific gravity of manometer fluid.

(iii) The correlation function at each test point is then calculated from the calibration data:

ER06OC93.209

Where:

(A) X_o = correlation function.

(B) D_p = The pressure differential from pump inlet to pump outlet, in. Hg. (kPa).

= P_{e-Pp}.

(C) P_e = Absolute pump outlet pressure, in. Hg. (kPa)

= P_B + PPO (Sp.Gr./13.5955) and

= P_B + PPO *for SI units.*

Where:

(D) PPO = Pressure head at pump outlet, in. fluid (kPa).

(iv) A linear least squares fit is performed to generate the calibration equation which has the form:

$$V_o = D_o − M(X_o)$$

D_o and M are the intercept and slope constants, respectively, describing the regression line.

(8) A CVS system that has multiple speeds should be calibrated on each speed used. The calibration curves generated for the ranges will be approximately parallel and the intercept values, D_o, will increase as the pump flow range decreases.

(9) If the calibration has been performed carefully, the calculated values from the equation will be within ±0.50 percent of the measured value of V_o. Values of M will vary from one pump to another, but values of D_o for pumps of the same make, model and range should agree within ±3 percent of each other. Particulate influx over time will cause the pump slip to decrease, as reflected by lower values for M. Calibrations should be performed at pump start-up and after major maintenance to assure the stability of the pump slip rate. Analysis of mass injection data will also reflect pump slip stability.

(d) *CFV calibration.* (1) Calibration of the CFV is based upon the flow equation for a critical venturi. Gas flow is a function of inlet pressure and temperature:

ER06OC93.210

Where:
(i) Q_s = flow.
(ii) K_v = calibration coefficient.
(iii) P = absolute pressure.
(iv) T = absolute temperature.

The calibration procedure described in paragraph (d)(3) of this section establishes the value of the calibration coefficient at measured values of pressure, temperature and air flow.

(2) The manufacturer's recommended procedure shall be followed for calibrating electronic portions of the CFV.

(3) Measurements necessary for flow calibration are as follows:

CALIBRATION DATA MEASUREMENTS

Parameter	Symbol	Units	Sensor-readout tolerances
Barometric pressure (corrected)	P_b	in Hg (kPa)	±.01 in Hg (±.034 kPa).
Air temperature, into flowmeter	ETI	°F (°C)	±0.5 °F (±0.28 °C).
Pressure drop between the inlet and throat of metering venturi	EDP	Inches H2O (kPa)	±0.05 in H$_2$O (±0.012 kPa).
Air flow	Q_s	Ft³/min. (m³/min.)	±5% of NBS "true" value.
CFV inlet depression	PPI	Inches fluid (kPa)	±.13 in fluid (±.055 kPa).
Temperature at venturi inlet	T_v	°F (°C)	±4.0 °F (±2.22 °C).
Specific gravity of manometer fluid (1.75 oil)	Sp. Gr		

(4) Set up equipment as shown in Figure N84–7 and eliminate leaks. (Leaks between the flow measuring devices and the critical flow venturi will seriously affect the accuracy of the calibration.)

(5) Set the variable flow restrictor to the open position, start the blower, and allow the system to stabilize. Record data from all instruments.

(6) Vary the flow restrictor and make at least eight readings across the critical flow range of the venturi.

(7) *Data analysis.* The data recorded during the calibration are to be used in the following calculations:

(i) The air flow rate, Q_s, at each test point is calculated in standard cubic feet per minute from the flow meter data using the manufacturer's prescribed method.

(ii) Calculate values of the calibration coefficient for each test point:

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Where:

(A) Q_s = Flow rate in standard cubic feet per minute, at the standard conditions of 68 °F, 29.92 in Hg (20 °C, 101.3 kPa).

(B) T_v = Temperature at venturi inlet, °R(°K).

(C) P_v = Pressure at venturi inlet, in. Hg. (kPA)
= P_B − PPI (Sp.GR./13.5955), and
= P_B − PPI *for SI units.*

Where:

(D) PPI = Venturi inlet pressure depression, in. fluid (kPA).

(E) Sp.Gr. = Specific gravity of manometer fluid.

(iii) Plot K_v as a function of venturi inlet pressure. For choked flow, K_v will have a relatively constant value. As pressure decreases (vacuum increases), the venturi becomes unchoked and K_v decreases. (See Figure N84–8.)

(iv) For a minimum of 8 points in the critical region calculate an average K_v and the standard deviation.

(v) If the standard deviation exceeds 0.3 percent of the average K_v, take corrective action.

(e) *CVS system verification.* The following ''gravimetric'' technique can be used to verify that the CVS and analyt-

ical instruments can accurately measure a mass of gas that has been injected into the system. (Verification can also be accomplished by constant flow metering using critical flow orifice devices.)

(1) Obtain a small cylinder that has been charged with pure propane or carbon monoxide gas (CAUTION—carbon monoxide is poisonous).

(2) Determine a reference cylinder weight to the nearest 0.01 grams.

(3) Operate the CVS in the normal manner and release a quantity of pure propane into the system during the sampling period (approximately 5 minutes).

(4) Following completion of step (3) above (if methanol injection is required), continue to operate the CVS in the normal manner and release a known quantity of pure methanol (in gaseous form) into the system during the sampling period (approximately five minutes). This step does not need to be performed with each verification, provided that it is performed at least twice annually.

(5) The calculations of § 86.1342 are performed in the normal way except in the case of propane. The density of propane (17.30 g/ft³/carbon atom (0.6109 kg/m³/carbon atom)) is used in place of the density of exhaust hydrocarbons. In the case of methanol, the density of 37.71 g/ft³ (1.332 kg/m³) is used.

(6) The gravimetric mass is subtracted from the CVS measured mass and then divided by the gravimetric mass to determine the percent accuracy of the system.

(7) The cause for any discrepancy greater than ±2 percent must be found and corrected. (For 1991–1995 calendar years, discrepancies greater than ±2 percent are allowed for the methanol test, provided that they do not exceed ±6 percent.)

(8) The Administrator, upon request, may waive the requirement to comply with ±2 percent methanol recovery tolerance, and instead require compliance with a higher tolerance (not to exceed ±6 percent), provided that:

(i) The Administrator determines that compliance with these specified tolerances is not practically feasible; and

(ii) The manufacturer makes information available to the Administrator which indicates that the calibration tests and their results are consistent with good laboratory practice, and that the results are consistent with the results of calibration testing conducted by the Administrator.

[54 FR 14591, Apr. 11, 1989, as amended at 60 FR 34371, June 30, 1995; 63 FR 24449, May 4, 1998]

§ 86.1320–90 Gas meter or flow instrumentation calibration; particulate, methanol, and formaldehyde measurement.

(a) Sampling for particulate, methanol and formaldehyde emissions requires the use of gas meters or flow instrumentation to determine flow through the particulate filters, methanol impingers and formaldehyde impingers. These instruments shall receive initial and periodic calibrations as follows:

(1)(i) Install a calibration device in series with the instrument. A critical flow orifice, a bellmouth nozzle, or a laminar flow element or an NBS traceable flow calibration device is required as the standard device.

(ii) The flow system should be checked for leaks between the calibration and sampling meters, including any pumps that may be part of the system, using good engineering practice.

(2) Flow air through the calibration system at the sample flow rate used for particulate, methanol, and formaldehyde testing and at the backpressure which occurs during the sample test.

(3) When the temperature and pressure in the system have stabilized, measure the indicated gas volume over a time period of at least five minutes or until a gas volume of at least ±1 percent accuracy can be determined by the standard device. Record the stabilized air temperature and pressure upstream of the instrument and as required for the standard device.

(4) Calculate air flow at standard conditions as measured by both the standard device and the instrument(s). (Standard conditions are defined as 68 °F (20 °C) and 29.92 in Hg (101.3 kPa).)

(5) Repeat the procedures of paragraphs (a) (2) through (4) of this section using at least two flow rates which bracket the typical operating range.

(6) If the air flow at standard conditions measured by the instrument differs by ±1.0 percent of the maximum operating range or ±2.0 percent of the point (whichever is smaller), then a correction shall be made by either of the following two methods:

(i) Mechanically adjust the instrument so that it agrees with the calibration measurement at the specified flow rates using the criteria of paragraph (a)(6) of this section, or

(ii) Develop a continuous best fit calibration curve for the instrument (as a function of the calibration device flow measurement) from the calibration points to determine corrected flow. The points on the calibration curve relative to the calibration device measurements must be within ±1.0 percent of the maximum operating range of ±2.0 percent of the point (whichever is smaller).

(7) For double dilution systems, the accuracy of the secondary dilution flow measurement device should be within ±1.0 percent of the total flow through the filter.

(b) *Other systems.* A bell prover may be used to calibrate the instrument if the procedure outlined in ANSI B109.1–1973 is used. Prior approval by the Administrator is not required to use the bell prover.

[54 FR 14593, Apr. 11, 1989]

§ 86.1321–90 Hydrocarbon analyzer calibration.

The FID hydrocarbon analyzer shall receive the following initial and periodic calibration. The HFID used with petroleum-fueled diesel engines shall be operated to a set point ±10 °F (±5.5 °C) between 365 and 385 °F (185 and 197 °C). The HFID used with methanol-fueled engines shall be operated at 235±15 °F (113±8 °C).

(a) *Initial and periodic optimization of detector response.* Prior to introduction into service and at least annually thereafter, the FID hydrocarbon analyzer shall be adjusted for optimum hydrocarbon response.

(1) Follow good engineering practices for initial instrument start-up and basic operating adjustment using the

appropriate fuel (see § 86.1314) and zero-grade air.

(2) Optimize the FID's response on the most common operating range. The response is to be optimized with respect to fuel pressure or flow while meeting the analyzer response time given in § 86.1310(b)(3)(vii)(A) for continuous HC measurement. Efforts shall be made to minimize response variations to different hydrocarbon species that are expected to be in the exhaust. Good engineering judgement is to be used to trade off optimal FID response to propane-in-air against reductions in relative responses to other hydrocarbons. A good example of trading off response on propane for relative responses to other hydrocarbon species is given in Society of Automotive Engineers (SAE) Paper No. 770141, ''Optimization of Flame Ionization Detector for Determination of Hydrocarbon in Diluted Automotive Exhausts''; author Glenn D. Reschke. It is also required that the response be set to optimum condition with respect to air flow and sample flow. Heated Flame Ionization Detectors (HFIDs) must be at their specified operating temperature.

(3) One of the following procedures is to be used for FID or HFID optimization:

(i) Use the procedures outlined in Society of Automotive Engineers (SAE) paper No. 770141, ''Optimization of Flame Ionization Detector for Determination of Hydrocarbons in Diluted Automobile Exhaust''; author, Glenn D. Reschke, as an example.

(ii) The HFID optimization procedures outlined in 40 CFR part 86, subpart D, § 86.331–79(c).

(iii) Alternative procedures may be used if approved in advance by the Administrator.

(iv) The procedures specified by the manufacturer of the FID or HFID.

(4) After the optimum fuel, air, and sample pressures or flow rates have been determined, they shall be recorded for future reference.

(b) *Initial and periodic calibration.* Prior to introduction into service and monthly thereafter, the FID or HFID hydrocarbon analyzer shall be calibrated on all normally used instrument ranges. Use the same flow rate and pressures as when analyzing samples. Calibration gases shall be introduced directly at the analyzer, unless the ''overflow'' calibration option of § 86.1310(b)(3)(i) for the HFID is taken.

(1) Adjust analyzer to optimize performance.

(2) Zero the hydrocarbon analyzer with zero-grade air.

(3) Calibrate on each used operating range with a minimum of 6, approximately equally spaced, propane-in-air calibration gases (e.g., 15, 30, 45, 60, 75, and 90 percent of that range). For each range calibrated, if the deviation from a least-squares best-fit straight line is within ±2 percent of the value at each non-zero data point and within ±0.3 percent of full scale on the zero data point, then concentration values may be calculated by using the linear calibration equation for that range. If the deviation exceeds these limits, then the best-fit non-linear equation which represents the data within these limits shall be used to determine concentration values.

(c) *FID response factor to methanol.* When the FID analyzer is to be used for the analysis of hydrocarbon samples containing methanol, the methanol response factor of the analyzer shall be established. The methanol response factor shall be determined at several concentrations in the range of concentrations in the exhaust sample.

(1) The bag sample of methanol for analysis in the FID shall be prepared using the apparatus shown in Figure N90–10. A known volume of methanol is injected, using a microliter syringe, into the heated mixing zone (250 °F (121 °C)) of the apparatus. The methanol is vaporized and swept into the sample bag with a known volume of zero-grade air measured by a dry gas meter.

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(2) The bag sample is analyzed using the FID.

(3) The FID response factor, r, is calculated as follows:

r = FIDppm/SAMppm

Where:
(i) r = FID response factor.
(ii) FIDppm = FID reading in ppmC.

(iii) SAMppm = methanol concentration in the sample bag in ppmC

ER06OC93.211

Where:
(iv) 0.02406 = volume of one mole at 29.92 in Hg and 68 °F, m³.

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(v) Fuel injected = volume of methanol injected, ml.

(vi) Fuel density = density of methanol, 0.7914 g/ml.

(vii) Air volume = volume of zero-grade air, m³.

(viii) Mol. Wt. CH₃OH = 32.04.

[54 FR 14594, Apr. 11, 1989, as amended at 62 FR 47128, Sept. 5, 1997]

§ 86.1321–94 Hydrocarbon analyzer calibration.

The FID hydrocarbon analyzer shall receive the following initial and periodic calibration. The HFID used with petroleum-fueled, natural gas-fueled and liquefied petroleum gas-fueled diesel engines shall be operated to a set point ±10 °F (±5.5 °C) between 365 and 385 °F (185 and 197 °C). The HFID used with methanol-fueled engines shall be operated at 235 ±15 °F (113 ±8 °C).

(a) Initial and periodic optimization of detector response. Prior to introduction into service and at least annually thereafter, the FID hydrocarbon analyzer shall be adjusted for optimum hydrocarbon response.

(1) Follow good engineering practices for initial instrument start-up and basic operating adjustment using the appropriate fuel (see § 86.1314) and zero-grade air.

(2) Optimize the FID's response on the most common operating range. The response is to be optimized with respect to fuel pressure or flow while meeting the analyzer response time given in § 86.1310(b)(3)(vii)(A) for continuous HC measurement. Efforts shall be made to minimize response variations to different hydrocarbon species that are expected to be in the exhaust. Good engineering judgement is to be used to trade off optimal FID response to propane-in-air against reductions in relative responses to other hydrocarbons. A good example of trading off response on propane for relative responses to other hydrocarbon species is given in Society of Automotive Engineers (SAE) Paper No. 770141, "Optimization of Flame Ionization Detector for Determination of Hydrocarbon in Diluted Automotive Exhausts"; author Glenn D. Reschke. It is also required that the response be set to optimum condition with respect to air flow and sample flow. Heated Flame Ionization

Detectors (HFIDs) must be at their specified operating temperature.

(3) One of the following procedures is to be used for FID or HFID optimization:

(i) Use the procedures outlined in Society of Automotive Engineers (SAE) paper number 770141, "Optimization of Flame Ionization Detector for Determination of Hydrocarbons in Diluted Automobile Exhaust"; author, Glenn D. Reschke, as an example. Available from Society of Automotive Engineers International, 400 Commonwealth Dr., Warrendale, PA 15096–0001.

(ii) The procedure listed in subpart D, § 86.331–79(c) of this part.

(iii) The procedures specified by the manufacturer of the FID or HFID.

(iv) Alternative procedures may be used if approved in advance by the Administrator.

(4) After the optimum fuel, air and sample pressures or flow rates have been determined, they shall be recorded for future reference.

(b) *Initial and periodic calibration.* Prior to introduction into service and monthly thereafter, the FID or HFID hydrocarbon analyzer shall be calibrated on all normally used instrument ranges. Use the same flow rate and pressures as when analyzing samples. Calibration gases shall be introduced directly at the analyzer, unless the "overflow" calibration option of § 86.1310(b)(3)(i) for the HFID is taken.

(1) Adjust analyzer to optimize performance.

(2) Zero the hydrocarbon analyzer with zero-grade air.

(3) Calibrate on each used operating range with a minimum of 6, approximately equally spaced, propane-in-air calibration gases (e.g., 15, 30, 45, 60, 75, and 90 percent of that range). For each range calibrated, if the deviation from a least-squares best-fit straight line is within ±2 percent of the value at each non-zero data point and within ±0.3 percent of full scale on the zero data point, then concentration values may be calculated by using the linear calibration equation for that range. If the deviation exceeds these limits, then the best-fit non-linear equation which represents the data within these limits shall be used to determine concentration values.

(c) *FID response factor to methanol.* When the FID analyzer is to be used for the analysis of hydrocarbon samples containing methanol, the methanol response factor of the analyzer shall be established. The methanol response factor shall be determined at several concentrations in the range of concentrations in the exhaust sample, using either bag samples or gas bottles meeting the requirements of §86.1314.

(1) The bag sample of methanol for analysis in the FID, if used, shall be prepared using the apparatus shown in Figure N94–10. A known volume of methanol is injected, using a microliter syringe, into the heated mixing zone (250 °F (121 °C)) of the apparatus. The methanol is vaporized and swept into the sample bag with a known volume of zero grade air measured by a gas flow meter meeting the specifications of §86.1320.

ER30JN95.051

(2) The bag sample is analyzed using the FID.

(3) The FID response factor, r, is calculated as follows:

$$r = FIDppm/SAMppm$$

Where:

(i) r=FID response factor.

(ii) FIDppm=FID reading in ppmC.

(iii) SAMppm=methanol concentration in the sample bag, or gas bottle, in ppmC. SAMppm for sample bags:

ER30JN95.038

Where:

(iv) 0.02406=volume of one mole at 29.92 in Hg and 68 °F, m³.

(v) Fuel injected = volume of methanol injected, ml.

(vi) Fuel density=density of methanol, 0.7914 g/ml.

(vii) Air volume=volume of zero-grade air, m³.

(viii) Mol. Wt. CH3OH=32.04.

(d) *FID response factor to methane.* When the FID analyzer is to be used for the analysis of natural gas-fueled vehicle hydrocarbon samples, the methane response factor of the analyzer shall be established. To determine the total hydrocarbon FID response to methane, known methane in air concentrations traceable to National Institute of Standards and Technology (NIST) shall be analyzed by the FID. Several methane concentrations shall be analyzed by the FID in the range of concentrations in the exhaust sample. The total hydrocarbon FID response to methane is calculated as follows:

r_{CH4}=FIDppm/SAMppm

Where:

(1) r_{CH4}=FID response factor to methane.

(2) FIDppm=FID reading in ppmC.

(3) SAMppm=the known methane concentration in ppmC.

[59 FR 48531, Sept. 21, 1994, as amended at 60 FR 34371, June 30, 1995; 62 FR 47128, Sept. 5, 1997]

§ 86.1322–84 Carbon monoxide analyzer calibration.

The NDIR carbon monoxide analyzer shall receive the following initial and periodic calibration.

(a) *Initial and periodic interference check.* Prior to its introduction into service and annually thereafter, the NDIR carbon monoxide analyzer shall be checked for response to water vapor and CO_2:

(1) Follow good engineering practices for instrument start-up and operation. Adjust the analyzer to optimize performance on the most sensitive range to be used.

(2) Zero the carbon monoxide analyzer with either zero-grade air or zero-grade nitrogen.

(3) Bubble a mixture of 3 percent CO_2 in N_2 through water at room temperature and record analyzer response.

(4) An analyzer response of more than 1 percent of full scale for ranges above 300 ppm full scale or more than 3 ppm on ranges below 300 ppm full scale requires corrective action. (Use of conditioning columns is one form of corrective action which may be taken.)

(b) *Initial and periodic calibration.* Prior to its introduction into service and monthly thereafter, the NDIR carbon monoxide analyzer shall be calibrated.

(1) Adjust the analyzer to optimize performance.

(2) Zero the carbon monoxide analyzer with either zero-grade air or zero-grade nitrogen.

(3) Calibrate on each used operating range with a minimum of 6, approximately equally spaced, carbon monoxide-in-N_2 calibration gases (e.g., 15, 30, 45, 60, 75, and 90 percent of that range). For each range calibrated, if the deviation from a least-squares best-fit straight line is within ±2 percent of the value at each non-zero data point and within ±0.3 percent of full scale on the zero data point, then concentration values may be calculated by using the linear calibration equation for that range. If the deviation exceeds these limits, then the best-fit not-linear equation which represents the data within these limits shall be used to determine concentration values.

(c) The initial and periodic interference, system check, and calibration test procedures specified in 40 CFR part 86, subpart D may be used in lieu of the procedures specified in this section.

[48 FR 52210, Nov. 16, 1983, as amended at 62 FR 47128, Sept. 5, 1997]

§ 86.1323–84 Oxides of nitrogen analyzer calibration.

The chemiluminescent oxides of nitrogen analyzer shall receive the following initial and periodic calibration.

(a) Prior to introduction into service and at least monthly thereafter, the chemiluminescent oxides of nitrogen

analyzer must be checked for NO2 to NO converter efficiency. Figure N84–9 is a reference for paragraphs (a) (1) through (11) of this section.

(1) Follow good engineering practices for instrument start-up and operation. Adjust the analyzer to optimize performance.

(2) Zero the oxides of nitrogen analyzer with zero-grade air or zero-grade nitrogen.

(3) Connect the outlet of the NO_X generator to the sample inlet of the ox-

ides of nitrogen analyzer which has been set to the most common operating range.

(4) Introduce into the NO_X generator analyzer-system an NO-in-nitrogen (N_2) mixture with an NO concentration equal to approximately 80 percent of the most common operating range. The NO_2 content of the gas mixture shall be less than 5 percent of the NO concentration.

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(5) With the oxides of nitrogen analyzer in the NO mode, record the con-

centration of NO indicated by the analyzer.

(6) Turn on the NO_X generator O_2 (or air) supply and adjust the O_2 (or air) flow rate so that the NO indicated by the analyzer is about 10 percent less than indicated in paragraph (a)(5) of this section. Record the concentration of NO in this NO + O_2 mixture.

(7) Switch the NO_X generator to the generation mode and adjust the generation rate so that the NO measured on the analyzer is 20 percent of that measured in paragraph (a)(5) of this section. There must be at least 10 percent unreacted NO at this point. Record the concentration of residual NO.

(8) Switch the oxides of nitrogen analyzer to the NO_X mode and measure total NO_X. Record this value.

(9) Switch off the NO_X generator but maintain gas flow through the system. The oxides of nitrogen analyzer will indicate the NO_X in the NO + O_2 mixture. Record this value.

(10) Turn off the NO_X generator O_2 (or air) supply. The analyzer will now indicate the NO_X in the original NO-in-N_2 mixture. This value should be no more than 5 percent above the value indicated in paragraph (a)(4) of this section.

(11) Calculate the efficiency of the NO_X converter by substituting the concentrations obtained into the following equation:

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Where:

a = concentration obtained in paragraph (a)(8),
b = concentration obtained in paragraph (a)(9),
c = concentration obtained in paragraph (a)(6),
d = concentration obtained in paragraph (a)(7).

If converter efficiency is not greater than 90 percent corrective action will be required.

(b) *Initial and periodic calibration.* Prior to its introduction into service and monthly thereafter, the chemiluminescent oxides of nitrogen analyzer shall be calibrated on all normally used instrument ranges. Use the same flow rate as when analyzing samples. Proceed as follows:

(1) Adjust analyzer to optimize performance.

(2) Zero the oxides of nitrogen analyzer with zero-grade air or zero-grade nitrogen.

(3) Calibrate on each used operating range with a minimum of 6, approximately equally spaced, NO-in-N_2 calibration gases (e.g., 15, 30, 45, 60, 75, and 90 percent of that range). For each range calibrated, if the deviation from a least-squares best-fit straight line is within ±2 percent of the value at each non-zero data point and within ±0.3 percent of full scale on the zero data point, then concentration values may be calculated using the linear calibration equation for that range. If the deviation exceeds these limits, then the best-fit non-linear equation which represents the data within these limits shall be used to determine concentration values.

(c) The initial and periodic interference, system check, and calibration test procedures specified in 40 CFR part 86, subpart D, may be used in lieu of the procedures specified in this section.

(d) When testing methanol-fueled engines it may be necessary to clean the analyzer frequently to prevent interference with NO_X measurements (see EPA/60/S3–88/040).

[48 FR 52210, Nov. 16, 1983, as amended at 49 FR 48144, Dec. 10, 1984; 58 FR 58426, Nov. 1, 1993; 60 FR 34374, June 30, 1995; 62 FR 47129, Sept. 5, 1997]

§ 86.1324–84 Carbon dioxide analyzer calibration.

Prior to its introduction into service and monthly thereafter, the NDIR carbon dioxide analyzer shall be calibrated as follows:

(a) Follow good engineering practices for instrument start-up and operation. Adjust the analyzer to optimize performance.

(b) Zero the carbon dioxide analyzer with either zero-grade air or zero-grade nitrogen.

(c) Calibrate on each used operating range with a minimum of 6, approximately equally spaced, carbon dioxide-in-N_2 calibration or span gases (e.g., 15, 30, 45, 60, 75, and 90 percent of that range). For each range calibrated, if the deviation from a least-squares best-fit straight line is within ±2 percent or

less of the value at each non-zero data point and within ±0.3 percent of full scale on the zero data point, then concentration values may be calculated by using the linear calibration equation for that range. If the deviation exceeds these limits, then the best-fit non-linear equation which represents the data within these limits shall be used to determine concentration values.

(d) The initial and periodic interference, system check, and calibration test procedures specified in 40 CFR part 86, subpart D, may be used in lieu of the procedures in this section.

[48 FR 52210, Nov. 16, 1983, as amended at 62 FR 47129, Sept. 5, 1997]

§ 86.1325–94 Methane analyzer calibration.

Prior to introduction into service and monthly thereafter, the methane analyzer shall be calibrated:

(a) Follow the manufacturer's instructions for instrument startup and operation. Adjust the analyzer to optimize performance.

(b) Zero the methane analyzer with zero-grade air.

(c) Calibrate on each used operating range with a minimum of 6, approximately equally spaced, CH4 in air calibration gases (e.g., 15, 40, 45, 60, 75, and 90 percent of that range). For each range calibrated, if the deviation from a least-squares best-fit straight line is within ±2 percent of the value at each non-zero data point and within ±0.3 percent of full scale on the zero data point, then concentration values may be calculated by using the linear calibration equation for that range. If the deviation exceeds these limits, then the best-fit non-linear equation which represents the data within these limits shall be used to determine concentration values.

[59 FR 48531, Sept. 21, 1994, as amended at 62 FR 47129, Sept. 5, 1997]

§ 86.1326–90 Calibration of other equipment.

Other test equipment used for testing shall be calibrated as often as required by the manufacturer or as necessary according to good practice. Specific equipment requiring calibration is the gas chromatograph and flame ionization detector used in measuring methanol and the high pressure liquid chromatograph (HPLC) and ultraviolet detector for measuring formaldehyde.

[54 FR 14596, Apr. 11, 1989]

§ 86.1327–90 Engine dynamometer test procedures; overview.

(a) The engine dynamometer test procedure is designed to determine the brake specific emissions of hydrocarbons, nonmethane hydrocarbons carbon monoxide, oxides of nitrogen, particulate, methanol and formaldehyde, as applicable. The test procedure consists of a ''cold'' start test following either natural or forced cool-down periods described in §§ 86.1334 and 86.1335, respectively. A ''hot'' start test follows the ''cold'' start test after a hot soak of 20 minutes. The idle test of subpart P of this part may be run after the ''hot'' start test. The exhaust emissions are diluted with ambient air and a continuous proportional sample is collected for analysis during both the cold- and hot-start tests. The composite samples collected are analyzed either in bags or continuously for hydrocarbons (HC), methane (CH$_4$—as applicable), carbon monoxide (CO), carbon dioxide (CO$_2$), and oxides of nitrogen (NO$_X$), or in sample collection impingers for methanol (CH$_3$OH) and sample collection impingers (or cartridges) for formaldehyde (HCHO). Measurement of CH$_3$OH and HCHO may be omitted for 1990 through 1994 model year methanol-fueled engines when a FID calibrated on methanol is used. A bag or continuous sample of the dilution air is similarly analyzed for background levels of hydrocarbon, carbon monoxide, carbon dioxide, and oxides of nitrogen and, if appropriate, methane and/or methanol and/or formaldehyde. In addition, for diesel-cycle engines, particulates are collected on fluorocarbon-coated glass fiber filters or fluorocarbon-based (membrane) filters, and the dilution air may be prefiltered.

(b) Engine torque and rpm command set points shall be issued at 5 (10 Hz recommended) Hz or greater during both the cold and hot start tests. Feedback engine torque and rpm shall be recorded at least once every second during the test.

(c) Using the torque and rpm feedback signals the brake horsepower is integrated with respect to time for the cold and hot cycles. This produces a brake horsepower-hour value that enables the brake-specific emissions to be determined (*see* § 86.1342, Calculations; gaseous exhaust emissions., and § 86.1343, Calculations; particulate exhaust emissions.).

(d)(1) When an engine is tested for exhaust emissions or is operated for service accumulation on an engine dynamometer, the complete engine shall be tested, with all emission control devices installed and functioning.

(2) Evaporative emission controls need not be connected if data are provided to show that normal operating conditions are maintained in the engine induction system.

(3) On air-cooled engines, the fan shall be installed.

(4) Additional accessories (*e.g.,* oil cooler, alternators, air compressors, etc.) may be installed or their loading simulated if typical of the in-use application.

(5) The engine may be equipped with a production type starter.

(e) Means of engine cooling which will maintain the engine operating temperatures (*e.g.,* temperatures of intake air, oil, water, etc.) at approximately the same temperature as specified by the manufacturer shall be used. Auxiliary fan(s) may be used to maintain engine cooling during operation on the dynamometer. Rust inhibitors and lubrication additives may be used, up to the levels recommended by the additive manufacturer. Antifreeze mixtures and other coolants typical of those approved for use by the manufacturer may be used.

(f) *Exhaust system.* The exhaust system shall meet the following requirements:

(1) *Gasoline-fueled and methanol-fueled Otto-cycle engines.* A chassis-type exhaust system shall be used. For all catalyst systems, the distance from the exhaust manifold flange(s) to the catalyst shall be the same as in the vehicle configuration unless the manufacturer provides data showing equivalent performance at another location. The catalyst container may be removed during all test sequences prior to the practice cycle, and replaced with an equivalent container having an inactive catalyst support.

(2) *Petroleum-fueled and methanol-fueled diesel engines.* Either a chassis-type or a facility-type exhaust system or both systems simultaneously may be used. If the engine is equipped with an exhaust aftertreatment device, the exhaust pipe must be the same diameter as found in-use for at least 4 pipe diameters upstream to the inlet of the beginning of the expansion section containing the aftertreatment device. The exhaust backpressure or restriction shall follow the same criteria as in § 86.1330–90(f) and may be set with a valve (muffler omitted). The catalyst container may be removed during all test sequences prior to the practice cycle, and replaced with an equivalent container having an inactive catalyst support.

(i) The engine exhaust system shall meet the following requirements:

(A) The total length of the tubing from the exit of the engine exhaust manifold, turbocharger outlet or aftertreatment device to the primary dilution tunnel shall not exceed 32 feet (9.8 m).

(B) The initial portion of the exhaust system may consist of a typical in-use (i.e., length, diameter, material, etc.) chassis-type exhaust system.

(C) The distance from the exhaust manifold flange(s) or turbocharger outlet to any exhaust aftertreatment device shall be the same as in the vehicle configuration or within the distance specifications provided by the manufacturer.

(D) For engines which are not equipped with exhaust aftertreatment devices, all tubing in excess of 12 feet (3.7 m) from the exit of the turbocharger or exhaust manifold shall be insulated. For engines equipped with exhaust aftertreatment devices, all tubing after the aftertreatment device which is in excess of 12 feet (3.7 m) shall be insulated.

(E) If the tubing is required to be insulated, the radial thickness of the insulation must be at least 1.0 inch (25 mm). The thermal conductivity of the insulating material must have a value no greater than 0.75 BTU-in/hr/ft²/°F

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(0.065 W/m-K) measured at 700 °F (371 °C).

(F) A smoke meter or other instrumentation may be inserted into the exhaust system tubing. If this option is exercised in the insulated portion of the tubing, then a minimal amount of tubing not to exceed 18 inches may be left uninsulated. However, no more than 12 feet (3.66 m) of tubing can be left uninsulated in total, including the length at the smoke meter.

(ii) The facility-type exhaust system shall meet the following requirements:

(A) It must be composed of smooth tubing made of typical in-use steel or stainless steel. This tubing shall have a maximum inside diameter of 6.0 in (15 cm).

(B) Short sections (altogether not to exceed 20 percent of the entire tube length) of flexible tubing at connection points are allowed.

[54 FR 14596, Apr. 11, 1989, as amended at 60 FR 34374, June 30, 1995; 62 FR 47129, Sept. 5, 1997]

§ 86.1327–94 Engine dynamometer test procedures; overview.

(a) The engine dynamometer test procedure is designed to determine the brake specific emissions of hydrocarbons, nonmethane hydrocarbons (for natural gas-fueled engines only), carbon monoxide, oxides of nitrogen, particulate (petroleum-fueled, natural gas-fueled, liquefied petroleum gas-fueled and methanol-fueled diesel engines), and methanol and formaldehyde (for methanol-fueled diesel engines). The test procedure consists of a ''cold'' start test following either natural or forced cool-down periods described in §§ 86.1334 and 86.1335, respectively. A ''hot'' start test follows the ''cold'' start test after a hot soak of 20 minutes. The idle test of subpart P may be run after the ''hot'' start test. The exhaust emissions are diluted with ambient air and a continuous proportional sample is collected for analysis during both the cold- and hot-start tests. The composite samples collected are analyzed either in bags or continuously for hydrocarbons (HC), methane (CH_4—for natural gas-fueled engines only), carbon monoxide (CO), carbon dioxide (CO_2), and oxides of nitrogen (NO_x), or in sample collection impingers for

methanol (CH_3OH) and sample collection impingers (or capsules) for formaldehyde (HCHO). Measurement of CH_3OH and HCHO may be omitted for 1990 through 1994 model year methanol-fueled engines when a FID calibrated on methanol is used. A bag or continuous sample of the dilution air is similarly analyzed for background levels of hydrocarbon, methane, carbon monoxide, carbon dioxide and oxides of nitrogen and, if appropriate, methanol and formaldehyde. In addition, for petroleum-fueled, natural gas-fueled, liquefied petroleum gas-fueled and methanol-fueled diesel engines, particulates are collected on fluorocarbon-coated glass fiber filters or fluorocarbon-based (membrane) filters, and the dilution air may be prefiltered.

(b) Engine torque and rpm command set points shall be issued at 5 (10 Hz recommended) Hz or greater during both the cold and hot start tests. Feedback engine torque and rpm shall be recorded at least once every second during the test.

(c) Using the torque and rpm feedback signals the brake horsepower is integrated with respect to time for the cold and hot cycles. This produces a brake horsepower-hour value that enables the brake-specific emissions to be determined (see § 86.1342, Calculations, gaseous exhaust emissions; and § 86.1343, Calculations, particulate exhaust emissions).

(d)(1) When an engine is tested for exhaust emissions or is operated for service accumulation on an engine dynamometer, the complete engine shall be tested, with all emission control devices installed and functioning.

(2) Evaporative emission controls need not be connected if data are provided to show that normal operating conditions are maintained in the engine induction system.

(3) On air-cooled engines, the fan shall be installed.

(4) Additional accessories (*e.g.,* oil cooler, alternators, air compressors, etc.) may be installed or their loading simulated if typical of the in-use application.

(5) The engine may be equipped with a production type starter.

(e) Means of engine cooling which will maintain the engine operating

temperatures (*e.g.,* temperatures of intake air, oil, water, etc.) at approximately the same temperature as specified by the manufacturer shall be used. Auxiliary fan(s) may be used to maintain engine cooling during operation on the dynamometer. Rust inhibitors and lubrication additives may be used, up to the levels recommended by the additive manufacturer. Antifreeze mixtures and other coolants typical of those approved for use by the manufacturer may be used.

(f) *Exhaust system.* The exhaust system shall meet the following requirements:

(1) *Otto-cycle engines.* A chassis-type exhaust system shall be used. For all catalyst systems, the distance from the exhaust manifold flange(s) to the catalyst shall be the same as in the vehicle configuration unless the manufacturer provides data showing equivalent performance at another location. The catalyst container may be removed during all test sequences prior to the practice cycle, and replaced with an equivalent container having an inactive catalyst support.

(2) *Diesel engines.* Either a chassis-type or a facility-type exhaust system or both systems simultaneously may be used. If the engine is equipped with an exhaust aftertreatment device, the exhaust pipe must be the same diameter as found in-use for at least 4 pipe diameters upstream to the inlet of the beginning of the expansion section containing the aftertreatment device. The exhaust backpressure or restriction shall follow the same criteria as in §86.1330–90 (f) and may be set with a valve (muffler omitted). The catalyst container may be removed during all test sequences prior to the practice cycle, and replaced with an equivalent container having an inactive catalyst support.

(i) The engine exhaust system shall meet the following requirements:

(A) The total length of the tubing from the exit of the engine exhaust manifold, turbocharger outlet or aftertreatment device to the primary dilution tunnel shall not exceed 32 feet (9.8 m).

(B) The initial portion of the exhaust system may consist of a typical in-use

(i.e., length, diameter, material, etc.) chassis-type exhaust system.

(C) The distance from the exhaust manifold flange(s) or turbocharger outlet to any exhaust aftertreatment device shall be the same as in the vehicle configuration or within the distance specifications provided by the manufacturer.

(D) For engines which are not equipped with exhaust aftertreatment devices, all tubing in excess of 12 feet (3.7 m) from the exit of the turbocharger or exhaust manifold shall be insulated. For engines equipped with exhaust aftertreatment devices, all tubing after the aftertreatment device which is in excess of 12 feet (3.7 m) shall be insulated.

(E) If the tubing is required to be insulated, the radial thickness of the insulation must be at least 1.0 inch (25 mm). The thermal conductivity of the insulating material must have a value no greater than 0.75 BTU-in/hr/ft^2/°F (0.065 W/m–K) measured at 700 °F (371 °C).

(F) A smoke meter or other instrumentation may be inserted into the exhaust system tubing. If this option is exercised in the insulated portion of the tubing, then a minimal amount of tubing not to exceed 18 inches may be left uninsulated. However, no more than 12 feet (3.66 m) of tubing can be left uninsulated in total, including the length at the smoke meter.

(ii) The facility-type exhaust system shall meet the following requirements:

(A) It must be composed of smooth tubing made of typical in-use steel or stainless steel. This tubing shall have a maximum inside diameter of 6.0 in (15 cm).

(B) Short sections (altogether not to exceed 20 percent of the entire tube length) of flexible tubing at connection points are allowed.

[59 FR 48532, Sept. 21, 1994, as amended at 62 FR 47129, Sept. 5, 1997]

§ 86.1327–96 Engine dynamometer test procedures; overview.

(a) The engine dynamometer test procedure is designed to determine the brake specific emissions of hydrocarbons, nonmethane hydrocarbons, carbon monoxide, oxides of nitrogen,

particulate, methanol and formaldehyde, as applicable. The test procedure consists of a ''cold'' start test following either natural or forced cool-down periods described in §§ 86.1334 and 86.1335, respectively. A ''hot'' start test follows the ''cold'' start test after a hot soak of 20 minutes. The idle test of subpart P of this part may be run after the ''hot'' start test. The exhaust emissions are diluted with ambient air and a continuous proportional sample is collected for analysis during both the cold- and hot-start tests. The composite samples collected are analyzed either in bags or continuously for hydrocarbons (HC), methane (CH_4) carbon monoxide (CO), carbon dioxide (CO_2), and oxides of nitrogen (NO_X), or in sample collection impingers for methanol (CH_3OH) and sample collection impingers (or cartridges) for formaldehyde (HCHO), as applicable. Measurement of CH_3OH and HCHO may be omitted for 1990 through 1994 model year methanol-fueled engines when a FID calibrated on methanol is used. A bag or continuous sample of the dilution air is similarly analyzed for background levels of hydrocarbon, carbon monoxide, carbon dioxide, and oxides of nitrogen and, if appropriate, methane and/or methanol and/or formaldehyde. In addition, for diesel-cycle engines, particulates are collected on fluorocarbon-coated glass fiber filters or fluorocarbon-based (membrane) filters, and the dilution air may be prefiltered.

(b) Engine torque and rpm command set points shall be issued at 5 (10 Hz recommended) Hz or greater during both the cold and hot start tests. Feedback engine torque and rpm shall be recorded at least once every second during the test.

(c) Using the torque and rpm feedback signals, integrate the brake horsepower with respect to time for the cold and hot cycles. This produces a brake horsepower-hour value that enables the brake-specific emissions to be determined (see §§ 86.1342 and 86.1343).

(d)(1) When an engine is tested for exhaust emissions or is operated for service accumulation on an engine dynamometer, the complete engine shall be tested, with all emission control devices installed and functioning.

(2) For gasoline- and methanol-fueled engines, evaporative emission canisters must be loaded with fuel vapors and connected to the engine. The canisters used for testing must be of the same design as those used in engine applications.

(3) On air-cooled engines, the fan shall be installed.

(4) Additional accessories (e.g., oil cooler, alternators, air compressors, etc.) may be installed or their loading simulated if typical of the in-use application.

(5) The engine may be equipped with a production-type starter.

(e) Means of engine cooling that will maintain the engine operating temperatures (e.g., temperatures of intake air, oil, water, etc.) at approximately the same temperature as specified by the manufacturer shall be used. An auxiliary fan(s) may be used to maintain engine cooling during operation on the dynamometer. Rust inhibitors and lubrication additives may be used, up to the levels recommended by the additive manufacturer. Antifreeze mixtures and other coolants typical of those approved for use by the manufacturer may be used.

(f) *Exhaust system.* The exhaust system term shall meet the following requirements:

(1) *Gasoline-fueled and methanol-fueled Otto-cycle engines.* A chassis-type exhaust system shall be used. For all catalyst systems, the distance from the exhaust manifold flange(s) to the catalyst shall be the same as in the vehicle configuration unless the manufacturer provides data showing equivalent performance at another location. The catalyst container may be removed during all test sequences prior to the practice cycle, and replaced with an equivalent container having an inactive catalyst support.

(2) Petroleum-fueled and methanol-fueled diesel engines. Either a chassis-type or a facility-type exhaust system or both systems simultaneously may be used. If the engine is equipped with an exhaust aftertreatment device, the exhaust pipe must be the same diameter as found in-use for at least 4 pipe diameters upstream to the inlet of the beginning of the expansion section containing the aftertreatment device. The

exhaust backpressure or restriction shall follow the same criteria as in §86.1330–90(f) and may be set with a valve (muffler omitted). The catalyst container may be removed during all test sequences prior to the practice cycle, and replaced with an equivalent container having an inactive catalyst support.

(i) The engine exhaust systems shall meet the following requirements:

(A) The total length of the tubing from the exit of the engine exhaust manifold, turbocharger outlet or aftertreatment device to the primary dilution tunnel shall not exceed 32 feet (9.8 m).

(B) The initial portion of the exhaust system may consist of a typical in-use (i.e., length, diameter, material, etc.) chassis-type exhaust system.

(C) The distance from the exhaust manifold flange(s) or turbocharger outlet to any exhaust aftertreatment device shall be the same as in the vehicle configuration or within the distance specifications provided by the manufacturer.

(D) For engines which are not equipped with exhaust aftertreatment devices, all tubing in excess of 12 feet (3.7 m) from the exit of the turbocharger or exhaust manifold shall be insulated. For engines equipped with exhaust aftertreatment devices, all tubing after the aftertreatment device which is in excess of 12 feet (3.7 m) shall be insulated.

(E) If the tubing is required to be insulated, the radial thickness of the insulation must be at least 1.0 inch (25 mm). The thermal conductivity of the insulating material must have a value no greater than 0.75 BTU-in/hr/ft^2/°F (0.065 W/m–K) measured at 700 °F (371 °C).

(F) A smoke meter or other instrumentation may be inserted into the exhaust system tubing. If this option is exercised in the insulated portion of the tubing, then a minimal amount of tubing not to exceed 18 inches may be left uninsulated. However, no more than 12 feet (3.66 m) of tubing can be left uninsulated in total, including the length at the smoke meter.

(ii) The facility-type exhaust system shall meet the following requirements:

(A) It must be composed of smooth tubing made of typical in-use steel or stainless steel. This tubing shall have a maximum inside diameter of 6.0 in (15 cm).

(B) Short sections (altogether not to exceed 20 percent of the entire tube length) of flexible tubing at connection points are allowed.

[58 FR 16064, Mar. 24, 1993, as amended at 59 FR 48533, Sept. 21, 1994; 60 FR 34374, June 30, 1995; 62 FR 47130, Sept. 5, 1997]

§ 86.1327–98 Engine dynamometer test procedures; overview.

Section 86.1327–98 includes text that specifies requirements that differ from §86.1327–96. Where a paragraph in §86.1327–96 is identical and applicable to §86.1327–98, this may be indicated by specifying the corresponding paragraph and the statement ''[Reserved]. For guidance see §86.1327–96''.

(a) through (d)(3) [Reserved]. For guidance see §86.1327–96.

(d)(4) Additional accessories (e.g., oil cooler, alternators, air compressors, etc.) may be installed or their loading simulated if typical of the in-use application. This loading shall be parasitic in nature and, if used, shall be applied during all engine testing operations, including mapping. The accessory work performed shall not be included in the integrated work used in emissions calculations.

(d)(5) through (f) [Reserved]. For guidance see §86.1327–96.

[62 FR 47130, Sept. 5, 1997]

§ 86.1330–84 Test sequence; general requirements.

(a) The test sequence shown in Figure N84–10 shows the major steps of the test procedure.

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(b) *Control of Air Temperature.* (1) The temperature of the CVS dilution air shall be maintained above 68 °F (20 °C) for Otto cycle engines and between 68 °F and 86 °F (20 °C and 30 °C) for diesel cycle engines throughout the test sequence, except as permitted by § 86.1335–84.

(2) For engines with auxiliary emission control devices which sense or detect ambient air temperature and operate at 68 °F or higher, the test cell ambient air temperature and the temperature of the engine intake air shall be maintained at 77 °F ±9 °F (25 °C ±5 °C) throughout the test sequence. For engines with auxiliary emission control devices which are temperature dependent and operate at 68 °F or higher, the temperature of the engine intake air shall be maintained at 77 °F ±9 °F (25 °C ±5 °C) throughout the test sequence.

(3) For engines which are not equipped with temperature dependent auxiliary emission control devices, the test cell ambient air temperature and the temperature of the engine intake air shall be greater than 20° C (68° F). No corrections will be made in test results or measured engine power if 30° C (86° F) is exceeded.

(4) The only exceptions to these temperatures are as noted in § 86.1335–84.

(5) For engines equipped with an air-to-air intercooler (or any other low temperature charge air cooling device) between the turbocharger compressor and the intake manifold, the procedure for simulating the device in the transient dynamometer test facilities shall follow the SAE Recommended Practice J1937, ''Engine Testing with Low Temperature Charge Air Cooling System in a Dynamometer Test Cell.''

(c) No control of ambient air, engine intake air or CVS dilution air humidity is required.

(d) The idle test of subpart P may be run after completion of the hot start exhaust emission test, if applicable.

(e) The barometric pressure observed during the generation of the maximum torque curve shall not deviate more than 1 inch Hg from the value measured at the beginning of the map. The average barometric pressure observed during the exhaust emission test must be within 1 inch Hg of the average observed during the maximum torque curve generation.

(f) *Diesel-Fueled Engines only.* (1)(i) Air inlet restriction shall be set to a value midway between a clean filter and the maximum restriction specified by the manufacturer. The exhaust restriction normally shall be set at 80 percent of the manufacturer's recommended maximum specified exhaust restriction. The manufacturer shall be liable for emission compliance from the minimum in-use restrictions to the maximum restrictions specified by the manufacturer for that particular engine.

(ii) Inlet depression and exhaust backpressure shall be set with the engine operating at rated speed and wide open throttle, except for the case of inlet depression for naturally aspirated

engines, which shall be set at maximum engine speed and nominal zero load (high idle).

(iii) The location at which the inlet depression and exhaust backpressure is measured shall be specified by the manufacturer.

(iv) The settings shall take place during the final mode of the preconditioning prior to determining the maximum torque curve.

(2)(i) The temperature of the inlet fuel to the engine shall not exceed 110 °F (or 130 °F during the first 10 seconds of the hot start test).

(ii) The pressure of the inlet fuel and the point at which it is measured shall be specified by the manufacturer.

(g) Pre-test engine measurements (e.g., governed diesel-fueled engine high idle speed, diesel-fueled engine fuel flows, etc.), pre-test engine performance checks (e.g., verification of actual rated rpm, etc.) and pre-test system calibrations (e.g., inlet and exhaust restrictions, etc.) shall be made prior to generation of the maximum torque curve. This can be done during engine preconditioning, or at the manufacturer's convenience subject to the requirements of good engineering practice.

[48 FR 52210, Nov. 16, 1983, as amended at 52 FR 47872, Dec. 16, 1987; 62 FR 47130, Sept. 5, 1997]

§ 86.1330–90 Test sequence; general requirements.

(a) The test sequence shown in Figure N84–10 shows the major steps of the test procedure.

(b) *Control of air temperature.* (1) The temperature of the CVS dilution air shall be maintained at greater than 68 °F (20 °C) for Otto cycle engines and between 68 °F and 86 °F (20 °C and 30 °C) for diesel cycle engines throughout the test sequence, except as permitted by § 86.1335–84.

(2) For engines with auxiliary emission control devices which sense or detect ambient air temperature and operate at 68 °F or higher, the test cell ambient air temperature and the temperature of the engine intake air shall be maintained at 77 °F ±9 °F (25 °C ±5 °C) throughout the test sequence. For engines with auxiliary emission control devices which are temperature depend-

ent and operate at 68 °F or higher, the temperature of the engine intake air shall be maintained at 77 °F ±9 °F (25 °C ±5 °C) throughout the test sequence.

(3) For engines which are not equipped with temperature dependent auxiliary emission control devices, the test cell ambient air temperature and the temperature of the engine intake air shall be greater than 68 °F (20 °C). No corrections will be made in test results or measured engine power if 86 °F (30 °C) is exceeded.

(4) The only exceptions to these temperatures are as noted in § 86.1335.

(5) For engines equipped with an air-to-air intercooler (or any other low temperature charge air cooling device) between the turbocharger compressor and the intake manifold, the procedure for simulating the device in the transient dynamometer test facilities shall follow the SAE Recommended Practice J1937, ''Engine Testing with Low Temperature Charge Air Cooling System in a Dynamometer Test Cell.''

(c) No control of ambient air, engine intake or CVS dilution air humidity is required (dehumidification of the dilution air prior to entering the CVS is allowed).

(d) The idle test of subpart P may be run after completion of the hot start exhaust emission test, if applicable.

(e) The barometric pressure observed during the generation of the maximum torque curve shall not deviate more than 1 in. Hg. from the value measured at the beginning of the map. The average barometric pressure observed during the exhaust emission test must be within 1 in. Hg. of the average observed during the maximum torque curve generation.

(f) *Petroleum-fueled and methanol-fueled diesel engines.* (1)(i) Air inlet restriction shall be set to a value midway between a clean filter and the maximum restriction specified by the manufacturer. The exhaust restriction normally shall be set at 80 percent of the manufacturer's recommended maximum specified exhaust restriction. The manufacturer shall be liable for emission compliance from the minimum in-use restrictions to the maximum restrictions specified by the manufacturer for that particular engine.

(ii) Inlet depression and exhaust backpressure shall be set with the engine operating at rated speed and wide open throttle, except for the case of inlet depression for naturally aspirated engines, which shall be set at maximum engine speed and nominal zero load (high idle).

(iii) The location at which the inlet depression and exhaust backpressure is measured shall be specified by the manufacturer.

(iv) The settings shall take place during the final mode of the preconditioning prior to determining the maximum torque curve.

(2)(i) The temperature of the inlet fuel to the engine shall not exceed 110 °F (or 130 °F during the first 10 seconds of the hot start test).

(ii) The pressure of the inlet fuel and the point at which it is measured shall be specified by the manufacturer.

(g) Pre-test engine measurements (e.g., governed petroleum-fueled or methanol-fueled diesel engine high idle speed, petroleum-fueled or methanol-fueled diesel engine fuel flows, etc.), pre-test engine performance checks (e.g., verification of actual rated rpm,

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or when a 3.0 percent drop in maximum horsepower occurs, whichever of the two is greater

(ii) For ungoverned engines using the transient operating cycle set forth in

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or when a 3.0 percent drop in maximum horsepower occurs, whichever of the two is greater

(iii) For governed engines the maximum mapped speed shall be no less than either that speed at which the wide-open throttle torque drops off to

etc.) and pre-test system calibrations (e.g., inlet and exhaust restrictions, etc.) shall be made prior to generation of the maximum torque curve. This can be done during engine preconditioning, or at the manufacturer s convenience subject to the requirements of good engineering practice.

[54 FR 14597, Apr. 11, 1989, as amended at 60 FR 34374, June 30, 1995; 62 FR 47131, Sept. 5, 1997]

§ 86.1332–90 Engine mapping procedures.

(a) Mount test engine on the engine dynamometer.

(b) Determine minimum mapping speed. The minimum speed is defined as the warm engine curb idle rpm.

(c) Determine maximum mapping speed per the following methodologies. (Note paragraph (d)(1) below.)

(1) *Otto-cycle engines.* (i) For ungoverned engines using the transient operating cycle set forth in paragraph (f)(1) of appendix I to this part, the maximum mapping speed shall be no less than that calculated from the following equation:

paragraph (f)(3) of appendix I to this part, the maximum mapping shall be no less than that calculated from the following equation:

zero, or the maximum speed as calculated for ungoverned engines (paragraph (c)(1)(i) of this section)

(2) *Diesel engines.* (i) For ungoverned engines, the maximum mapping speed shall be no less than that calculated from the following equation:

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or when a 3.0 drop in horsepower occurs, whichever of the two is greater

(ii) For governed engines, the maximum mapping speed shall be no less than either that speed at which wide-open throttle torque drops off to zero, or the maximum speed as calculated for ungoverned engines (paragraph (c)(2)(i) of this section).

(d) Perform an engine power map.

(1) During engine preparation or warm-up, the engine may be operated such that a preliminary estimate of measured rated rpm can be made.

(2) *Otto-cycle engines.* (i) For a cold engine, start the engine and operate at zero load in accordance with the manufacturer's start-up and warm-up procedures for 1 minute ±30 seconds.

(ii) Operate the engine at a torque equivalent to 10±3 percent of the most recent determination of maximum torque for 4 minutes ±30 seconds at 2000 rpm.

(iii) Operate the engine at a torque equivalent to 55±5 percent of the most recent determination of maximum torque for 35 minutes ±1 minute at 2000 rpm.

(iv) Operate the engine at idle (minimum speed).

(v) Open the throttle fully.

(vi) While maintaining wide-open throttle and full-load, maintain minimum engine speed for at least 15 seconds. Record the average torque during the last 5 seconds.

(vii) In no greater than 100±20 rpm increments, determine the maximum torque curve from minimum speed to maximum speed. Hold each test point for 15 seconds, and record the average torque over the last 5 seconds.

(viii) *Alternate mapping technique.* In place of paragraphs (d)(2) (vi) and (vii) of this section, a continual sweep of rpm is allowed. While operating at wide-open throttle, the engine speed is increased at an average rate of 8 rpm/sec (±1 rpm/sec) from minimum speed to maximum speed. Speed and torque points shall be recorded at a sample rate of at least one point per second.

(ix) Recalculate the maximum speed per paragraph (c)(1) (i) or (ii) of this section using the measured rated speed derived from the new maximum torque curve. If the new maximum speed lies outside the range of speeds encompassed by the actual map, then the map shall be considered void, and another map will need to be run using the newly derived measured rated speed in all calculations.

(x) For warm engines, the entire warm-up procedure specified in paragraphs (d)(2) (i) through (iii) of this section need not be repeated. It is sufficient for an engine already at normal operating temperatures to be operated at the conditions specified in paragraph (d)(2)(iii) of this section until oil and water temperatures are stabilized, after which the procedures of paragraph (d)(2) (iv) through (vii) of this section may be performed. The oil and water temperatures are defined as stabilized if they are maintained within 2 percent of point for 2 minutes.

(3) *Diesel engines.* (i) If the engine is cold, start and operate at free idle for 2 to 3 minutes.

(ii) Operate the engine at approximately 50 percent power at the peak torque speed for 5 to 7 minutes.

(iii) Operate the engine at rated speed and wide-open throttle for 25 to 30 minutes.

(iv) *Option.* The engine may be preconditioned by operating at rated speed and maximum horsepower until the oil and water temperatures are stabilized. The temperatures are defined as stabilized if they are maintained within 2 percent of point for 2 minutes. This optional procedure may be substituted for paragraph (d)(3)(iii) of this section.

(v) Unload the engine and operate at the curb idle speed.

(vi) Operate the engine at wide open throttle and minimum engine speed. Increase the engine speed at an average rate of 8 rpm/sec (±1 rpm/sec) from minimum to maximum speed. Engine speed and torque points shall be recorded at a sample rate of at least one point per second.

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(vii) Recalculate the maximum speed per paragraph (c)(2) (i) or (ii) of this section using the measured rated speed derived from the new maximum torque curve. If the new maximum speed lies outside the range of speeds encompassed by the actual map, then the map shall be considered void. The entire mapping procedure shall be repeated, using the newly derived measured rated speed in all calculations.

(viii) For warm engines, the entire warm-up procedure specified in paragraphs (d)(3) (i) through (iv) of this section need not be repeated. It is sufficient for an engine already at normal operating temperatures to be operated per the requirements of paragraph (d)(3)(iv) of this section, after which the procedures of paragraph (d)(3) (v) through (vi) of this section may be performed.

(e) Mapping curve generation.

(1) *Otto-cycle engines.* (i) Fit all data points recorded under paragraphs (d)(2) (vi) and (vii) of this section (100 rpm increments) with a cubic spline, Akima, or other technique approved in advance by the Administrator. The resultant curve shall be accurate to within ±1.0 ft-lbs of all recorded engine torques.

(ii) All points generated under the continuous rpm sweep by paragraphs (d)(2) (vi) and (viii) of this section shall be connected by linear interpolation between points.

(iii) For governed engines, all points above the maximum speed (see paragraph (c)(1)(ii) of this section) shall be assigned maximum torque values of zero for purposes of cycle generation.

(iv) For all engines, all speed points below the minimum speed shall be assigned a maximum torque value equal to that observed at minimum speed for purposes of cycle generation.

(v) The torque curve resulting from paragraphs (e)(1) (i) through (iv) of this section is the mapping curve and will be used to convert the normalized torque values in the engine cycle (*see* paragraph (f)(1) of appendix I to this part) to actual torque values for the test cycle.

(2) *Diesel engines.* (i) Connect all data points recorded under paragraph (d)(3)(vi) of this section using linear interpolation between points.

(ii) For governed engines, all points above the maximum speed (*see* paragraph (c)(2)(ii) of this section) shall be assigned maximum torque values of zero for purposes of cycle generation.

(iii) For all engines, all speed points below the minimum speed shall be assigned a maximum torque value equal to that observed at the minimum speed for purposes of cycle generation.

(iv) The torque curve resulting from paragraphs (e)(2) (i) through (iii) of this section is the mapping curve and will be used to convert the normalized torque values in the engine cycle (*see* paragraph (f)(2) of appendix I to this part) into actual torque values for the test cycle.

(f) *Alternate mapping.* If a manufacturer believes that the above mapping techniques are unsafe or unrepresentative for any given engine or engine family, alternate mapping techniques may be used. These alternate techniques must satisfy the intent of the specified mapping procedures to determine the maximum available torque at all engine speeds achieved during the test cycles. Deviations from the mapping techniques specified in this section for reasons of safety or representativeness shall be reported per § 86.1344(e)(6), along with the justification for their use. In no case, however, shall descending continual sweeps of rpm be used for governed or turbocharged engines.

(g) *Replicate Tests.* An engine need not be mapped before each and every cold cycle test. An engine shall be remapped prior to a cold cycle test if:

(1) An unreasonable amount of time has transpired since the last map, as determined by engineering judgment, or

(2) The barometric pressure prior to the start of the cold cycle test has changed more than 1 in hg. from the average barometric pressure observed durinq the map, or

(3) Physical changes or recalibrations have been made to the engine which may potentially affect engine performance.

[54 FR 14597, Apr. 11, 1989, as amended at 59 FR 48533, Sept. 21, 1994]

§86.1333–90 Transient test cycle generation.

(a) The heavy-duty transient engine cycles for Otto-cycle and diesel engines are listed in appendix I ((f) (1), (2) and (3)) to this part. These second-by-second listings represent torque and rpm maneuvers characteristic of heavy-duty engines. Both rpm and torque are normalized (expressed as a percentage of maximum) in these listings.

(1) To unnormalize rpm, use the following equation:

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The method of calculating measured rated rpm is detailed in paragraph (g) of this section.

(2) Torque is normalized to the maximum torque at the rpm listed with it. Therefore, to unnormalize the torque values in the cycle, the maximum torque curve for the engine in question must be used. The generation of the maximum torque curve is described in §86.1332.

(3) The EPA Engine Dynamometer Schedule for Heavy Duty Diesel Engines listed in appendix I (f)(2) contains torque points referred to as ''closed rack motoring.'' For reference cycle calculation torque points shall take on unnormalized values determined in either of the following three ways:

(i) Negative 40 percent of the positive torque available at the associated speed point. The generation of this positive maximum torque curve is described in §86.1332.

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(2) *Determine actual torque:* Determine the maximum observed torque at 1976 rpm from the maximum torque curve. Then multiply this value (*e.g.,* 358 ft-

(ii) Map the amount of negative torque required to motor the engine between idle and maximum mapping speed and use this map to determine the amount of negative torque required at the associated speed point.

(iii) Determine the amount of negative torque required to motor the engine at idle and rated speeds and linearly interpolate using these two points.

(b) *Example of the unnormalization procedure.* The following test point shall be unnormalized:

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Given the following values:
  Measured Rated rpm = 3800.
  Curb Idle rpm = 600.
  (1) *Calculate actual rpm:*

lbs) by 0.82. This results in an actual torque of 294 ft-lbs.

(c) Engine speed and torque shall be recorded at least once every second during the cold start test and hot start test. The torque and rpm feedback signals may be filtered.

(d) *Cold start enhancement devices.* The zero percent speed specified in the engine dynamometer schedules (appendix I (f)(1), (f)(2) or (f)(3) to this part) shall be superseded by proper operation of

the engine's automatic cold start enhancement device.

(1) During automatic cold start enhancement device operation, a manual transmission engine shall be allowed to idle at whatever speed is required to produce a feedback torque of 0 ft-lbs. ±10 ft-lbs. (using, for example, clutch disengagement, speed to torque control switching, software overrides, etc.) at those points in appendix I (f)(1), (f)(2), or (f)(3) to this part where both reference speed and reference torque are zero percent values.

(2) During automatic cold start enhancement device operation, an automatic transmission engine shall be allowed to idle at whatever speed is required to produce a feedback torque of CITT ft-lbs. ±10 ft-lbs. (see paragraph (e)(2) of this section for definition of CITT) at those points in appendix I (f)(1), (f)(2), or (f)(3) to this part where both reference speed and reference torque are zero percent values.

(e) *Automatic transmissions.* The reference cycles in paragraphs (f) (1) and (2) of appendix I to this part shall be altered for test engines intended primarily for use with automatic transmissions.

(1) Zero percent speed for automatic transmission engines is defined as curb idle rpm (*i.e.,* in-vehicle, coupled with automatic transmission in gear).

(2) All zero-percent speed, zero-percent torque points (idle points) shall be modified to zero percent speed, Curb Idle Transmission Torque (CITT), except as permitted in §86.1337–90(a)(9). Also, all points with speed equal to or less than zero percent and torque less than CITT shall be modified to CITT. Motoring torque shall remain unchanged. In order to provide a smooth torque transition, all consecutive torque points that are between 0 and CITT shall be changed to CITT if the first of these is preceded or the last of these is succeeded by idle points. The manufacturer's specified CITT shall be based upon that value observed in typical applications at the mean of the manufacturers' specified idle speed range at stabilized temperature conditions.

(f) *Clutch operation.* Manual transmission engines may be tested with a clutch. If used, the clutch shall be dis-

engaged at all zero percent speeds, zero percent torque points, but may be engaged up to two points preceeding a non-zero point, and may be engaged for time segments with zero percent speed and torque points of durations less than four seconds. (*See* §86.1341 for allowances in the cycle validation criteria.)

(g) *Measured rated rpm.* The measured rated rpm corresponds to the 100 percent rpm values specified in the reference cycles (paragraphs (f) (1) and (2) of appendix I to this part). It is generally intended to represent the rpm at which maximum brake horsepower occurs. For the purposes of this test sequence, it shall either be defined as the manufacturer's specified rated speed, or calculated in the following way, whichever yields the higher speed:

(1) From the maximum torque curve generated per §86.1332, find the maximum observed brake horsepower of the engine.

(2) Calculate 98 percent of the observed maximum brake horsepower, and determine from the maximum torque curve the highest and lowest engine rpms at which this brake horsepower is observed.

(3) The highest and lowest of the 98 percent power rpms represent the endpoints of an rpm range. The midpoint of this range shall be considered the measured rated rpm for cycle generation purposes.

[54 FR 14599, Apr. 11, 1989, as amended at 62 FR 47131, Sept. 5, 1997; 63 FR 24449, May 4. 1998]

§ 86.1334–84   Pre-test engine and dynamometer preparation.

(a) *Control system calibration.* (1) Before the cold soak or cool down, final calibration of the dynamometer and throttle control systems may be performed. These calibrations may consist of steady-state operations and/or actual practice cycle runs.

(2) Following any practice runs or calibration procedures, the engine shall be cooled per §86.1335–90.

(b) [Reserved]

[48 FR 52210, Nov. 16, 1983, as amended at 49 FR 48145, Dec. 10, 1984; 52 FR 47874, Dec. 16, 1987; 62 FR 47131, Sept. 5, 1997]

§ 86.1335–90 Cool-down procedure.

(a) This cool-down procedure applies to Otto-cycle and diesel engines.

(b) Engines may be soaked at ambient conditions. No substances or fluids may be applied to the engine's internal or external surfaces except for water and air as prescribed in paragraphs (c) and (d) of this section.

(c) For water-cooled engines, two types of cooling are permitted:

(1) Water may be circulated through the engine's water coolant system.

(i) The coolant may be flowed in either direction and at any desired flow rate. The thermostat may be removed or blocked open during the cool-down but must be restored before the exhaust emissions test begins.

(ii) The temperature of the circulated or injected water shall be at least 10 °C (50 °F). In addition, the temperature of the cooling water shall not exceed 30 °C (86 °F) during the last 30 minutes of the cool-down.

(iii) Only water, including the use of a building's standard water supply, or the coolant type that is already in the engine (per § 86.1327–90(e)) is permitted for cool-down purposes.

(2) Flows of air may be directed at the exterior of the engine.

(i) The air shall be directed essentially uniformly over the exterior surface of the engine at any desired flow rate.

(ii) The temperature of the cooling air shall not exceed 86 °F (30 °C) during the last 30 minutes of the cool-down, but may be less than 68 °F (20 °C) at any time.

(d) For air-cooled engines, only cooling as prescribed in paragraph (c)(2) of this section is permitted.

(e)(1) The cold cycle exhaust emission test may begin after a cool-down only when the engine oil and water temperatures are stabilized between 68 °F and 86 °F (20 °C and 30 °C) for a minimum of fifteen minutes.

(i) These temperature measurements are to be made by temperature measurement devices immersed in the sump oil and in the thermostat housing or cylinder head cooling circuit, the sensor parts of which are not in contact with any engine surface.

(ii) The flow of oil and water shall be shut off during this measurement. Air flow, except as necessary to keep the cell temperature between 68 °F and 86 °F (20 °C and 30 °C), shall be shut off. No engine oil change is permitted during the test sequence.

(2) Direct cooling of engine oil through the use of oil coolers or heat exchangers is permitted. The cold cycle emission test may begin only when the requirements in paragraph (e)(1)(ii) are met.

(3) Any other means for the direct cooling of the engine oil must be approved in advance by the Administrator.

(f)(1) The cold cycle exhaust emission test for engines equipped with exhaust aftertreatment devices may begin after a cool-down only when the aftertreatment device is 77 °F ±9 °F (25 °C ±5 °C), in addition to the temperature restrictions in paragraph (e) of this section. For catalysts, this temperature must be measured at the outlet of the catalyst bed.

(2) Exhaust aftertreatment device cool-down may be accomplished in whatever manner and using whatever coolant deemed appropriate by proper engineering judgment. The aftertreatment device, engine, and exhaust piping configurations shall not be separated, altered, or moved in any way during the cool-down.

(g) For engines with auxiliary emission control devices which are temperature dependent, the cold start shall not begin until the temperature readings of the auxiliary emission control devices are stable at 77 °F ±9 °F (25 °C ±5 °C).

(h) At the completion of the cool-down all of the general requirements specified in § 86.1330, the oil temperature specification set forth in paragraph (e) of this section, and the catalyst temperature specifications in paragraph (f) of this section must be met before the cold cycle exhaust emission test may begin.

[62 FR 47131, Sept. 5, 1997]

§ 86.1336–84 Engine starting, restarting, and shutdown.

(a) The engine shall be started according to the manufacturer's recommended starting procedure in the

owner's manual, using either a production starter motor or the dynamometer. The speed at which the engine is cranked (motored) with the dynamometer shall be equal to the cranking speed (nominal speed ±10 percent) in the vehicle with a fully charged battery. The time taken to accelerate the engine to cranking speed by the dynamometer shall be equal (nominal ±0.5 seconds) to the time required with a starter motor. Motoring by the dynamometer shall be terminated not more than one second after the engine starts. The 24 ±1-second free idle period, and declutching if applicable, shall begin when the engine is determined to have started.

(1) Engines equipped with automatic chokes shall be operated according to the manufacturer's operating instructions in the owner's manual, including choke setting and ''kick-down'' from cold fast idle.

(2) Engines equipped with manual chokes shall be operated according to the manufacturer's operating instructions in the owner's manual.

(3) The operator may use the choke, throttle, etc. where necessary to keep the engine running.

(4) If the manufacturer's operating instructions in the owner's manual do not specify a warm engine starting procedure, the engine (automatic and manual choke engines) shall be started by depressing the throttle half way and cranking the engine until it starts.

(b)(1) If the engine does not start after 15 seconds of cranking, cranking shall cease and the reason for failure to start shall be determined. The gas flow measuring device (or revolution counter) on the constant volume sampler (and the hydrocarbon integrator when testing diesel-fueled engines) shall be turned off during this diagnostic period. In addition, either the CVS should be turned off or the exhaust tube disconnected from the tailpipe during the diagnostic period. If failure to start is an operational error, the engine shall be rescheduled for testing from a cold start.

(2) If longer cranking times are necessary and recommended to the ultimate purchaser, such cranking times may be used in lieu of the 15-second limit, provided the owner's manual and the service repair manual indicate that the longer cranking times are normal.

(3) If a failure to start occurs during the cold portion of the test and is caused by an engine malfunction, corrective action of less than 30 minutes duration may be taken (according to §86.084–25), and the test continued. The sampling system shall be reactivated at the same time cranking begins. When the engine starts, the timing sequence shall begin. If failure to start is caused by engine malfunction and the engine cannot be started, the test shall be voided and corrective action may be taken according to §86.084–25.

(4) If a failure to start occurs during the hot start portion of the test and is caused by engine malfunction, the engine must be started within one minute of key on. The sampling system shall be reactivated at the same time cranking begins. When the engine starts, the transient engine cycle timing sequence shall begin. If the engine cannot be started within one minute of key on, the test shall be voided, corrective action taken (according to §86.084–25), and the engine rescheduled for testing.

(c) *Engine stalling.* (1) If the engine stalls during the initial idle period of either the cold or hot start test, the engine shall be restarted immediately using the appropriate cold or hot starting procedure and the test continued.

(2) If the engine stalls anywhere in the cold cycle, except in the initial idle period, the test shall be voided.

(3) If the engine stalls on the hot cycle portion of the test at any time other than the initial idle, the engine may be shut off and resoaked for 20 minutes. The hot cycle may then be rerun. Only one hot start resoak and restart is permitted.

(d) *Engine shutdown.* Engine shutdown shall be performed in accordance with manufacturer's specifications.

(e) *Test equipment malfunction*—(1) *Gasoline- and methanol-fueled engines.* If a malfunction occurs in any of the required test equipment during the test run, the test shall be voided.

(2) *Diesel-fueled, natural gas-fueled and liquefied petroleum gas-fueled engines.* (i) If a malfunction occurs in any of the required test equipment during the cold cycle portion of the test, the test shall be voided.

(ii) If a malfunction occurs in any of the required test equipment (computer, gaseous emissions analyzer, etc.) during the hot cycle portion of the test, complete the full engine cycle before engine shut-down then resoak for 20 minutes.

(A) If the test equipment malfunction can be corrected before the resoak period has been completed, the hot cycle portion of the test may be rerun.

(B)(*1*) If the test equipment malfunction is corrected after the completion of the resoak period, then the preconditioning cycle must be run before the hot cycle. This consists of a full 20 minute transient cycle followed by a 20 minute soak and then the for-record hot cycle.

(*2*) In no case can the start of the cold cycle and the start of the hot cycle be separated by more than 4 hours.

§ 86.1337–90 Engine dynamometer test run.

(a) The following steps shall be taken for each test:

(1) Prepare the engine, dynamometer, and sampling system for the cold-start test. Change filters, etc., and leak check as necessary.

NOTE: For a single dilution particulate system, a propane check will not reveal a pressure side leak (that portion of the system downstream of the pump) since the volume concentration in ppm will not change if a portion of the sample is lost. A separate leak check is needed.

A leak check of a filter assembly that has only one seal ring in contact with the filter media will not detect a leak when tested under vacuum. A pressure leak test should be performed.

(2) Connect evacuated sample collection bags to the dilute exhaust and dilution air sample collection systems.

(3) For methanol-fueled vehicles, install fresh methanol and formaldehyde impingers (or cartridges) in the exhaust and dilution air sample systems for methanol and formaldehyde. A single dilution air sample covering the total test period may be utilized for methanol and formaldehyde background. (Background measurements of methanol and formaldehyde may be omitted and concentrations assumed to be zero for calculations in § 86.1344.)

(4) Attach the CVS to the engine exhaust system any time prior to starting the CVS.

(5) Start the CVS (if not already on), the sample pumps (except for the particulate sample pump(s), if applicable), the engine cooling fan(s), and the data collection system. The heat exchanger of the constant volume sampler (if used), and the heated components of any continuous sampling system(s) (if applicable) shall be preheated to their designated operating temperatures before the test begins. (*See* § 86.1340(e) for continuous sampling procedures.)

(6) Adjust the sample flow rates to the desired flow rates and set the CVS gas flow measuring devices to zero.

NOTE: CFV–CVS sample flow rate is fixed by the venturi design.

(7) For diesel engines tested for particulate emissions, carefully install a clean particulate sample filter into each of the filter holders and install the assembled filter holders in the sample flow line (filter holders may be preassembled).

(8) Follow the manufacturers choke and throttle instructions for cold starting. Simultaneously start the engine and begin exhaust and dilution air sampling. For petroleum-fueled diesel engines (and natural gas-fueled, liquified petroleum gas-fueled or methanol-fueled diesels, if used), turn on the hydrocarbon and NO_X (and CO and CO_2, if continuous) analyzer system integrators (if used), and turn on the particulate sample pumps and indicate the start of the test on the data collection medium.

(9) As soon as it is determined that the engine is started, start a "free idle" timer. Allow the engine to idle freely with no-load for 24 ±1 seconds. This idle period for automatic transmission engines may be interpreted as an idle speed in neutral or park. All other idle conditions shall be interpreted as an idle speed in gear. It is permissible to lug the engine down to

curb idle speed during the last 8 seconds of the free idle period for the purpose of engaging dynamometer control loops.

(10) Begin the transient engine cycles such that the first non-idle record of the cycle occurs at 25±1 seconds. The free idle time is included in the 25±1 seconds.

(i) During diesel particulate sampling it must be demonstrated that the ratio of main tunnel flow to particulate sample flow does not change by more than ±5.0 percent of its set point value (except for the first 10 seconds of sampling).

NOTE: For double dilution operation, sample flow is the net difference between the flow rate through the sample filters and the secondary dilution air flow rate.

(ii) Record the average temperature and pressure at the gas meter(s) or flow instrumentation inlet, where needed to calculate flow. If the set flow rate cannot be maintained because of high particulate loading on the filter, the test shall be terminated. The test shall be rerun using a lower flow rate and/or a larger diameter filter.

(11) Begin the transient engine cycles such that the first non-idle record of the cycle occurs at 25 ±1 seconds. The free idle time is included in the 25 ±1 seconds.

(12) On the last record of the cycle, cease sampling. Immediately turn the engine off, and start a hot-soak timer. Also turn off the particulate sample pumps, the gas flow measuring device(s) and any continuous analyzer system integrators and indicate the end of the test on the data collection medium. Sampling systems should continue to sample after the end of the test cycle until system response times have elapsed.

(13) Immediately after the engine is turned off, turn off the engine cooling fan(s) if used, and the CVS blower (or disconnect the exhaust system from the CVS). As soon as possible, transfer the ''cold start cycle'' exhaust and dilution air bag samples to the analytical system and process the samples according to §86.1340. A stabilized reading of the exhaust sample on all analyzers shall be obtained within 20 minutes of the end of the sample collection phase of the test. Analysis of the methanol

and formaldehyde samples shall be obtained within 24 hours of the end of the sample collection period. For petroleum-fueled and methanol-fueled diesel engines, carefully remove the filter holder from the sample flow apparatus, and remove each particulate sample filter from its holder and invert the secondary filter and place it stain side to stain side on top of the primary filter. Place the filter pair in a petri dish and cover.

(14) Allow the engine to soak for 20±1 minutes.

(15) Prepare the engine and dynamometer for the hot start test.

(16) Connect evacuated sample collection bags to the dilute exhaust and dilution air sample collection systems.

(17) Install fresh methanol and formaldehyde impingers (or capsules) in the exhaust and dilution air sample systems for methanol and formaldehyde.

(18) Start the CVS (if not already on) or connect the exhaust system to the CVS (if disconnected). Start the sample pumps (except the particulate sample pump(s), if applicable), the engine cooling fan(s) and the data collection system. The heat exchanger of the constant volume sampler (if used) and the heated components of any continuous sampling system(s) (if applicable) shall be preheated to their designated operating temperatures before the test begins. See §86.1340(e) for continuous sampling procedures.

(19) Adjust the sample flow rates to the desired flow rate and set the CVS gas flow measuring devices to zero.

(20) For diesel engines tested for particulate, carefully install a clean particulate filter in each of the filter holders and install assembled filter holders in the sample flow line (filter holders may be preassembled).

(21) Follow the manufacturer's choke and throttle instruction for hot starting. Simultaneously start the engine and begin exhaust and dilution air sampling. For diesel engines, turn on the hydrocarbon and NO_X (and CO and CO_2, if continuous) analyzer system integrators (if used), indicate the start of the test on the data collection medium, and turn on the particulate sample pump(s).

(22) As soon as it is determined that the engine is started, start a ''free idle'' timer.

(23) Allow the engine to idle freely with no-load for 24 ±1 seconds. The provisions and interpretations of paragraph (a)(9) of this section apply.

(24) Begin the transient-engine cycle such that the first non-idle record of the cycle occurs at 25±1 seconds. The free idle is included in the 25±1 seconds.

(25) On the last record of the cycle, allow sampling system response times to elapse and cease sampling. Turn off the particulate sample pump(s) (if appropriate), the gas flow measuring device(s) and any continuous analyzer system integrators and indicate the end of the test on the data collection medium.

(26) As soon as possible, transfer the ''hot start cycle'' exhaust and dilution air bag samples to the analytical system and process the samples according to § 86.1340. A stabilized reading of the exhaust sample on all analyzers shall be obtained within 20 minutes of the end of the sample collection phase of the test. Analyze the methanol and formaldehyde samples within 24 hours. (If it is not possible to perform analysis within 24 hours, the samples should be stored in a cold (approximately 0 °C) dark environment until analysis can be performed). For petroleum-fueled and methanol-fueled diesel engines, carefully remove the assembled filter holder from the sample flow lines and remove each particulate sample filter from its holder and invert the secondary filter and place it stain side to stain side on top of the primary filter. Place the filter pairs in a clean petri dish and cover as soon as possible. Within 1 hour after the end of the hot start phase of the test, transfer the particulate filters to the weighing chamber for post-test conditioning.

(27) The CVS and the engine may be turned off, if desired.

(b) The procedure in paragraph (a) of this section is designed for one sample bag for the cold start portion and one for the hot start portion. It is also permissible to use more than one sample bag per test portion.

(c) If a dynamometer test run is determined to be void, corrective action may be taken. The engine may then be allowed to cool (naturally or forced) and the dynamometer test rerun per paragraph (a) or (b) of this section.

[54 FR 14600, Apr. 11, 1989, as amended at 59 FR 48533, Sept. 21, 1994; 60 FR 34374, June 30, 1995; 62 FR 47132, Sept. 5, 1997]

§ 86.1337–96 Engine dynamometer test run.

(a) The following steps shall be taken for each test:

(1) *Prepare for the cold-start test.* (i) For gasoline- and methanol-fueled engines only, evaporative emission canisters shall be prepared for use in this testing in accordance with the procedures specified in § 86.1232–96 (h) or (j). The size of the canisters used for testing shall correspond with the largest canister capacity expected in the range of vehicle applications for each engine. The Administrator may, at his discretion, use a smaller canister capacity. Attach the evaporative emission canister(s) to the engine, using the canister purge plumbing and controls employed in vehicle applications of the engine being tested. Plug the canister port that is normally connected to the fuel tank.

(ii) Prepare the engine, dynamometer, and sampling system.

(iii) Change filters, etc., and leak check as necessary. For a single dilution particulate system, a propane check will not reveal a pressure side leak (that portion of the system downstream of the pump) since the volume concentration in ppm will not change if a portion of the sample is lost. A separate leak check is needed. A leak check of a filter assembly that has only one seal ring in contact with the filter media will not detect a leak when tested under vacuum. A pressure leak test should be performed.

(2) Connect evacuated sample collection bags to the dilute exhaust and dilution air sample collection systems.

(3) For methanol-fueled vehicles, install fresh methanol and formaldehyde impingers (or cartridges) in the exhaust and dilution air sample systems for methanol and formaldehyde. A single dilution air sample covering the total test period may be utilized for methanol and formaldehyde background. (Background measurements of methanol and formaldehyde

may be omitted and concentrations assumed to be zero for calculations in § 86.1344.)

(4) Attach the CVS to the engine exhaust system any time prior to starting the CVS.

(5) Start the CVS (if not already on), the sample pumps (except for the particulate sample pump(s), if applicable), the engine cooling fan(s), and the data collection system. The heat exchanger of the constant volume sampler (if used), and the heated components of any continuous sampling system(s) (if applicable) shall be preheated to their designated operating temperatures before the test begins. (See § 86.1340(e) for continuous sampling procedures.)

(6) Adjust the sample flow rates to the desired flow rates and set the CVS gas flow measuring devices to zero. CFV–CVS sample flow rate is fixed by the venturi design.

(7) For diesel engines tested for particulate emissions, carefully install a clean particulate sample filter into each of the filter holders and install the assembled filter holders in the sample flow line (filter holders may be preassembled).

(8) Follow the manufacturer's choke and throttle instructions for cold starting. Simultaneously start the engine and begin exhaust and dilution air sampling. For petroleum-fueled diesel engines (and natural gas-fueled, liquified petroleum gas-fueled or methanol-fueled diesels, if used) turn on the hydrocarbon and NO_X (and CO and CO_2, if continuous) analyzer system integrators (if used), and turn on the particulate sample pumps and indicate the start of the test on the data collection medium.

(9) As soon as it is determined that the engine is started, start a "free idle" timer. Allow the engine to idle freely with no-load for 24±1 seconds. This idle period for automatic transmission engines may be interpreted as an idle speed in neutral or park. All other idle conditions shall be interpreted as an idle speed in gear. It is permissible to lug the engine down to curb idle speed during the last 8 seconds of the free idle period for the purpose of engaging dynamometer control loops.

(10) Begin the transient engine cycles such that the first non-idle record of the cycle occurs at 25±1 seconds. The free idle time is included in the 25±1 seconds.

(i) During diesel particulate sampling it must be demonstrated that the ratio of main tunnel flow to particulate sample flow does not change by more than ±5.0 percent of its set point value (except for the first 10 seconds of sampling). For double dilution operation, sample flow is the net difference between the flow rate through the sample filters and the secondary dilution air flow rate.

(ii) Record the average temperature and pressure at the gas meter(s) or flow instrumentation inlet, where needed to calculate flow. If the set flow rate cannot be maintained because of high particulate loading on the filter, the test shall be terminated. The test shall be rerun using a lower flow rate and/or a larger diameter filter.

(11) Begin the transient engine cycles such that the first non-idle record of the cycle occurs at 25±1 seconds. The free idle time is included in the 25±1 seconds.

(12) On the last record of the cycle, cease sampling. Immediately turn the engine off and start a hot-soak timer. Also turn off the particulate sample pumps, the gas flow measuring device(s) and any continuous analyzer system integrator and indicate the end of the test on the data collection medium. Sampling systems should continue to sample after the end of the test cycle until system response times have elapsed.

(13) Immediately after the engine is turned off, turn off the engine cooling fan(s) if used, and the CVS blower (or disconnect the exhaust system from the CVS). As soon as possible, transfer the "cold start cycle" exhaust and dilution air bag samples to the analytical system and process the samples according to § 86.1340. A stabilized reading of the exhaust sample on all analyzers shall be obtained within 20 minutes of the end of the sample collection phase of the test. Analysis of the methanol and formaldehyde samples shall be obtained within 24 hours of the end of the sample collection period. For petroleum-fueled and methanol-fueled diesel

engines, carefully remove the filter holder from the sample flow apparatus, remove each particulate sample filter from its holder and invert the secondary filter and place it stain side to stain side on top of the primary filter. Place the filter pair in a petri dish and cover.

(14) Allow the engine to soak for 20±1 minutes.

(15) Prepare the engine and dynamometer for the hot start test.

(16) Connect evacuated sample collection bags to the dilute exhaust and dilution air sample collection systems.

(17) Install fresh methanol and formaldehyde impingers (or capsules) in the exhaust and dilution air sample systems for methanol and formaldehyde.

(18) Start the CVS (if not already on) or connect the exhaust system to the CVS (if disconnected). Start the sample pumps (except the particulate sample pump(s), if applicable), the engine cooling fan(s) and the data collection system. The heat exchanger of the constant volume sampler (if used) and the heated components of any continuous sampling system(s) (if applicable) shall be preheated to their designated operating temperatures before the test begins. See §86.1340(e) for continuous sampling procedures.

(19) Adjust the sample flow rates to the desired flow rate and set the CVS gas flow measuring devices to zero.

(20) For diesel engines tested for particulate, carefully install a clean particulate filter in each of the filter holders and install assembled filter holders in the sample flow line (filter holders may be preassembled).

(21) Follow the manufacturer's choke and throttle instruction for hot starting. Simultaneously start the engine and begin exhaust and dilution air sampling. For diesel engines, turn on the hydrocarbon and NO_x (and CO and CO_2, if continuous) analyzer system integrator (if used), indicate the start of the test on the data collection medium, and turn on the particulate sample pump(s).

(22) As soon as it is determined that the engine is started, start a ''free idle'' timer.

(23) Allow the engine to idle freely with no-load for 24±1 seconds. The pro-

visions and interpretations of paragraph (a)(9) of this section apply.

(24) Begin the transient-engine cycle such that the first non-idle record of the cycle occurs at 25±1 seconds. The free idle is included in the 25±1 seconds.

(25) On the last record of the cycle, allow sampling system response times to elapse and cease sampling. Turn off the particulate sample pump(s) (if appropriate), the gas flow measuring device(s) and any continuous analyzer system integrator and indicate the end of the test on the data collection medium.

(26) As soon as possible, transfer the ''hot start cycle'' exhaust and dilution air bag samples to the analytical system and process the samples according to §86.1340. A stabilized reading of the exhaust sample on all analyzers shall be obtained within 20 minutes of the end of the sample collection phase of the test. Analyze the methanol and formaldehyde samples within 24 hours. (If it is not possible to perform analysis within 24 hours, the samples should be stored in a cold (approximately 0 °C) dark environment until analysis can be performed). For petroleum-fueled and methanol-fueled diesel engines, carefully remove the assembled filter holder from the sample flow lines and remove each particulate sample filter from its holder and invert the secondary filter and place it stain side to stain side on top of the primary filter. Place the filter pairs in a clean petri dish and cover as soon as possible. Within 1 hour after the end of the hot start phase of the test, transfer the particulate filters to the weighing chamber for post-test conditioning.

(27) The CVS and the engine may be turned off, if desired.

(b) The procedure in paragraph (a) of this section is designed for one sample bag for the cold start portion and one for the hot start portion. It is also permissible to use more than one sample bag per test portion.

(c) If a dynamometer test run is determined to be void, corrective action may be taken. The engine may then be allowed to cool (naturally or forced)

and the dynamometer test rerun per paragraph (a) or (b) of this section.

§ 86.1338–84 Emission measurement accuracy.

(a) *Measurement accuracy—Bag sampling.* (1) Good engineering practice dictates that exhaust emission sample analyzer readings below 15 percent of full scale chart deflection should generally not be used.

(2) Some high resolution read-out systems such as computers, data loggers, etc., can provide sufficient accuracy and resolution below 15 percent of full scale. Such systems may be used provided that additional calibrations of at least 4 non-zero nominally equally spaced points, using good engineering judgement, below 15 percent of full scale are made to ensure the accuracy of the calibration curves.

(3) The following procedure shall be followed:

(i) Span the analyzer using a calibration gas that meets the accuracy requirements of § 86.1314–84(f)(2), is within the operating range of the analyzer and at least 90% of full scale.

(ii) Generate calibration data over the full concentration range at a minimum of 6, approximately equally spaced, points (e.g. 15, 30, 45, 60, 75 and 90 percent of the range of concentrations provided by the gas divider). If a gas divider or blender is being used to calibrate the analyzer and the requirements of paragraph (a)(2) of this section are met, verify that a second calibration gas with a concentration between 10 and 20 percent of full scale can be named within 2 percent of its certified concentration. If more calibration points are needed to meet the requirements of paragraph (a)(2) of this section, continue with paragraph (a)(3)(iii) of this section.

(iii) If a gas divider or blender is being used to calibrate the analyzer, input the value of a second calibration gas (a span gas may be used for calibrating a CO_2 analyzer) having a named concentration between 10 and 20 percent of full scale. This gas shall be included on the calibration curve. Continue adding calibration points by di-

viding this gas until the requirements of paragraph (a)(2) of this section are met.

(iv) Fit a calibration curve per §§ 86.1321 through 86.1324 for the full scale range of the analyzer using the calibration data obtained with both calibration gases.

(b) *Measurement accuracy—Continuous sampling.* (1) Analyzers used for continuous analysis must be operated such that the measured concentration falls between 15 and 100 percent of full scale chart deflection. Exceptions to these limits are:

(i) Analyzer response less than 15 percent or more than 100 percent of full scale may be used if automatic range change circuitry is used and the limits for range changes are between 15 and 100 percent of full scale chart deflection;

(ii) Analyzer response less than 15 percent of full scale may be used if one of the following is true:

(A) Alternative (a)(2) of this section is used to ensure that the accuracy of the calibration curve is maintained below 15 percent; or

(B) The full scale value of the range is 155 ppm (C) or less.

(iii) Analyzer response over 100% of full scale may be used if it can be shown that readings in this range are accurate.

(iv) The HC and CO readings are allowed to ''spike'' above full scale of the analyzer's maximum operating range for a maximum accumulation of 5 seconds. These analyzer readings shall default to the maximum readable value during this time.

(c) If a gas divider is used, the gas divider shall conform to the accuracy requirements specified in § 86.1314–84(g), and shall be used according to the procedures contained in (a) and (b) of this section.

§ 86.1339–90 Particulate filter handling and weighing.

(a) At least 1 hour before the test, place a filter pair in a closed (to eliminate dust contamination) but unsealed (to permit humidity exchange) petri dish and place in a weighing chamber meeting the specifications of § 86.1312 for stabilization.

(b) At the end of the stabilization period, weigh each filter pair on a balance having a precision of 20 micrograms and a readability of 10 micrograms. This reading is the tare weight of the filter pair and must be recorded (see § 86.1344(e)(18)).

(c) The filter pair shall then be stored in a covered petri dish or a sealed filter holder, either of which shall remain in the weighing chamber until needed for testing.

(d) If the filter pair is not used within 1 hour of its removal from the weighing chamber, it must be re-weighed before use. This limit of 1 hour may be replaced by an 8-hour limit if either of the following three conditions are met:

(1) A stabilized filter pair is placed and kept in a sealed filter holder assembly with the ends plugged; or

(2) A stabilized filter pair is placed in a sealed filter holder assembly, which is then immediately placed in a sample line through which there is no flow; or

(3) A combination of the conditions specified in paragraphs (d) (1) and (2) of this section.

(e) After the emissions test, remove the filters from the filter holder and place them face to face in a covered but unsealed petri dish. They must then be conditioned in the weighing chamber for at least one hour. The filters are then weighed as a pair. This reading is the gross weight of the filters (Pf) and must be recorded (see § 86.1344–90(e)(19)).

(f) The net particulate weight (Pf) on each filter pair is the gross weight minus the tare weight. Should the sample on the filters (exhaust or background) contact the petri dish or any other surface, the test is void and must be rerun.

(g) Static neutralizers shall be used on petri dishes in accordance with good engineering judgement.

[62 FR 47134, Sept. 5, 1997]

§ 86.1340–90 Exhaust sample analysis.

(a) The analyzer response may be read by automatic data collection (ADC) equipment such as computers, data loggers, etc. If ADC equipment is used the following is required:

(1) For bag analysis, the analyzer response must be stable at greater than 99 percent of the final reading for the dilute exhaust sample bag. A single value representing the average chart deflection over a 10-second stabilized period shall be stored. For the background bag, all readings taken during the 10-second interval must be stable at the final value to within ±1 percent of full scale.

(2) For continuous analysis systems, the ADC system must read at least two analyzer readings per second. A single value representing the average integrated concentration over a cycle shall be stored.

(3) The chart deflections or average integrated concentrations required in paragraphs (a) (1) and (2) of this section may be stored on long-term computer storage devices such as computer tapes, storage discs, punch cards, or they may be printed in a listing for storage. In either case a chart recorder is not required and records from a chart recorder, if they exist, need not be stored.

(4) If the data from ADC equipment is used as permanent records, the ADC equipment and the analyzer values as interpreted by the ADC equipment are subject to the calibration specifications in §§ 86.1316 through 86.1326, as if the ADC equipment were part of the analyzer.

(b) Data records from any one or a combination of analyzers may be stored as chart recorder records.

(c) *Software zero and span.* (1) The use of ''software'' zero and span is permitted. The process of software zero and span refers to the technique of initially adjusting the analyzer zero and span responses to the calibration curve values, but for subsequent zero and span checks the analyzer response is simply recorded without adjusting the analyzer gain. The observed analyzer response recorded from the subsequent check is mathematically corrected back to the calibration curve values for zero and span. The same mathematical correction is then applied to the analyzer's response to a sample of exhaust gas in order to compute the true sample concentration.

(2) The maximum amount of software zero and span mathematical correction is ±10 percent of full scale chart deflection.

(3) Software zero and span may be used to switch between ranges without adjusting the gain of the analyzer.

(4) The software zero and span technique may not be used to mask analyzer drift. The observed chart deflection before and after a given time period or event shall be used for computing the drift. Software zero and span may be used after the drift has been computed to mathematically adjust any span drift so that the ''after'' span check may be transformed into the ''before'' span check for the next segment.

(d) For bag sample analysis perform the following sequence:

(1) Warm-up and stabilize the analyzers; clean and/or replace filter elements, conditioning columns (if used), etc., as necessary.

(2) Obtain a stable zero reading.

(3) Zero and span the analyzers with zero and span gases. The span gases shall have concentrations between 75 and 100 percent of full-scale chart deflection. The flow rates and system pressures during spanning shall be approximately the same as those encountered during sampling. A sample bag may be used to identify the required analyzer range.

(4) Re-check zero response. If this zero response differs from the zero response recorded in paragraph (d)(3) of this section by more than 1 percent of full scale, then paragraphs (d) (2), (3), and (4) of this section should be repeated.

(5) If a chart recorder is used, identify and record the most recent zero and span response as the pre-analysis values.

(6) If ADC equipment is used, electronically record the most recent zero and span response as the pre-analysis values.

(7) Measure HC (except diesels), CO, CO_2, and NO_X sample and background concentrations in the sample bag(s) with approximately the same flow rates and pressures used in paragraph (d)(3) of this section. (Constituents measured continuously do not require bag analysis.)

(8) A post-analysis zero and span check of each range must be performed and the values recorded. The number of events that may occur between the pre

and post checks is not specified. However, the difference between pre-analysis zero and span values (recorded in paragraph (d) (5) or (6) of this section) versus those recorded for the post-analysis check may not exceed the zero drift limit or the span drift limit of 2 percent of full scale chart deflection for any range used. Otherwise the test is void.

(e) For continuous sample analysis perform the following sequence:

(1) Warm-up and stabilize the analyzers; clean and/or replace filter elements, conditioning columns (if used), etc., as necessary.

(2) Leak check portions of the sampling system that operate at negative gauge pressures when sampling, and allow heated sample lines, filters, pumps, etc., to stabilize at operating temperature.

(3) *Optional:* Perform a hang-up check for the HFID sampling system:

(i) Zero the analyzer using zero air introduced at the analyzer port.

(ii) Flow zero air through the overflow sampling system. Check the analyzer response.

(iii) If the overflow zero response exceeds the analyzer zero response by 2 percent or more of the HFID full-scale deflection, hang-up is indicated and corrective action must be taken.

(iv) The complete system hang-up check specified in paragraph (f) of this section is recommended as a periodic check.

(4) Obtain a stable zero reading.

(5) Zero and span each range to be used on each analyzer used prior to the beginning of the cold cycle. The span gases shall have a concentration between 75 and 100 percent of full scale chart deflection. The flow rates and system pressures shall be approximately the same as those encountered during sampling. The HFID analyzer shall be zeroed and spanned through the overflow sampling system.

(6) Re-check zero response. If this zero response differs from the zero response recorded in paragraph (e)(5) of this section by more than 1 percent of full scale, then paragraphs (e) (4), (5), and (6) of this section should be repeated.

(7) If a chart recorder is used, identify and record the most recent zero

and span response as the pre-analysis values.

(8) If ADC equipment is used, electronically record the most recent zero and span response as the pre-analysis values.

(9) Measure the emissions (HC required for diesels; NO_X, CO, CO_2 optional) continuously during the cold start cycle. Indicate the start of the test, the range(s) used, and the end of the test on the recording medium (chart paper or ADC equipment). Maintain approximately the same flow rates and system pressures used in paragraph (e)(5) of this section.

(10) Collect background HC, CO, CO_2, and NO_X in a sample bag.

(11) Perform a post-analysis zero and span check for each range used at the conditions specified in paragraph (e)(5) of this section. Record these responses as the post-analysis values.

(12) Neither the zero drift nor the span drift between the pre-analysis and post-analysis checks on any range used may exceed 3 percent for HC, or 2 percent for NO_X, CO, and CO_2, of full scale chart deflection, or the test is void. (If the HC drift is greater than 3 percent of full-scale chart deflection, hydrocarbon hang-up is likely.)

(13) Determine HC background levels for the cold start cycle by introducing the background sample into the overflow sample system.

(14) Determine background levels of NO_X, CO, or CO_2 (if necessary) by the bag technique outlined in paragraph (d) of this section.

(15) Repeat paragraphs (e)(4) through (14) of this section for the hot cycle. The post-analysis zero and span check for the cold start (or previous hot start) cycle may be used for the pre-analysis zero and span for the following hot start cycle.

(f) *HC hang-up.* If HC hang-up is indicated, the following sequence may be performed:

(1) Fill a clean sample bag with background air.

(2) Zero and span the HFID at the analyzer ports.

(3) Analyze the background air sample bag through the analyzer ports.

(4) Analyze the background air through the entire sample probe system.

(5) If the difference between the readings obtained is 2 percent or more of the HFID full scale deflection, clean the sample probe and the sample line.

(6) Reassemble the sample system, heat to specified temperature, and repeat the procedure in paragraphs (f) (1) through (6) of this section.

(g) For CH_3OH (where applicable), introduce test samples into the gas chromatograph and measure the concentration. This concentration is C_{MS} in the calculations.

(h) For HCHO (where applicable), introduce test samples into the high pressure liquid chromatograph and measure the concentration of formaldehyde as a dinitrophenylhydrazine derivative in acetonitrile. This concentration is C_{FS} in the calculations.

[54 FR 14602, Apr. 11, 1989, as amended at 60 FR 34375, June 30, 1995]

§ 86.1340–94 Exhaust sample analysis.

Section 86.1340–94 includes text that specifies requirements that differ from § 86.1340–90. Where a paragraph in § 86.1340–90 is identical and applicable to § 86.1340–94, this may be indicated by specifying the corresponding paragraph and the statement ''[Reserved]. For guidance see § 86.1340–90.''

(a) through (d)(6) [Reserved]. For guidance see § 86.1340–90.

(d)(7) Measure HC (except diesels), CH_4 (natural gas-fueled engines only), CO, CO_2, and NO_X sample bag(s) with approximately the same flow rates and pressures used in § 86.1340–90(d)(3). (Constituents measured continuously do not require bag analysis.)

(d)(8) through (h) [Reserved]. For guidance see § 86.1340–90.

[59 FR 48534, Sept. 21, 1994, as amended at 60 FR 34375, June 30, 1995]

§ 86.1341–90 Test cycle validation criteria.

(a) To minimize the biasing effect of the time lag between the feedback and reference cycle values, the entire engine speed and torque feedback signal sequence may be advanced or delayed in time with respect to the reference speed and torque sequence. If the feedback signals are shifted, both speed and torque must be shifted the same amount in the same direction.

(b) *Brake horsepower-hour calculation.* (1) Calculate the brake horsepower-hour for each pair of engine feedback speed and torque values recorded. Also calculate the reference brake horsepower-hour for each pair of engine speed and torque reference values. Calculations shall be to five significant digits.

(2) In integrating the reference and the feedback horsepower-hour, all negative torque values shall be set equal to zero and included. If integration is performed at a frequency of less than 5 Hz, and if during a given time segment, the torque value changes from positive to negative or negative to positive, then the negative portion must be computed by linear interpolation and set equal to zero and the positive portion included. The same methodology shall be used for integrating both reference and actual brake horsepower-hour.

(c) *Regression line analysis to calculate validation statistics.* (1) Linear regressions of feedback value on reference value shall be performed for speed, torque and brake horsepower on 1 Hz data after the feedback shift has occurred (see paragraph (a) of this section). The method of least squares shall be used, with the best fit equation having the form:

y=mx+b

Where:

y = The feedback (actual) value of speed (rpm), torque (ft-lbs), or brake horsepower.
m = Slope of the regression line.
x = The reference value (speed, torque, or brake horsepower).
b = The y-intercept of the regression line.

(2) The standard error of estimate (SE) of y on x and the coefficient of determination (r^2) shall be calculated for each regression line.

(3) For a test to be considered valid, the criteria in Figure N90–11 must be met for both cold and hot cycles individually. Point deletions from the regression analyses are permitted where noted in Figure N90–11.

Figure N90–11

Regression Line Tolerances

	Speed	Torque	BHP
Petroleum-fueled and methanol-fueled diesel engines			
Standard error of estimate (SE) of Y on X	100 rpm	13 pct. of power map maximum engine torque	8 pct. of power map maximum BHP.
Slope of the regression line, m	0.970 to 1.030	0.83–1.03 (hot), 0.77–1.03 (cold)	0.89–1.03 (hot), 0.87–1.03 (cold).
Coefficient of determination, r^2	[1]0.9700	[1]0.8800 (hot), [1]0.8500 (cold)	[1]0.9100.
Y intercept of the regression line, b	50 ρτημ	15 φτ-λβ	5.0
Gasoline-fueled and methanol-fueled Otto-cycle engines			
Standard error of estimate (SE) of Y on X	100 rpm	10% (hot), 11% (cold) of power map max. engine torque.	5% (hot), 6% (cold) of power map maximum BHP.
Slope of the regression line, m	0.980 to 1.020	0.92–1.03 (hot), 0.88–1.03 (cold)	0.93–1.03 (hot), 0.89–1.03 (cold).
Coefficient of determination, r^2	[1]0.9700	[1]0.9300 (hot), [1]0.9000 (cold)	[1]0.9400 (hot), [1]0.9300 (cold).
Y intercept of the regression line, b	25 (hot), 40 (cold)	4%(hot), 5 (cold) of power map max. engine torque.	2.0% (hot), 2.5% (cold) of power map BHP.

[1] Minimum.

PERMITTED POINT DELETIONS FROM REGRESSION ANALYSIS

Condition	Points to be deleted
1. Wide Open Throttle and Torque Feedback < Torque Reference	Torque, and/or BHP.
2. Closed Throttle, Not an Idle Point, Torque Feedback > Torque Reference	Torque, and/or BHP.
3. Closed Throttle, Idle Point, and Torque Feedback = CITT (10 ft-lb)	Speed, and/or BHP.

For the purposes of this discussion:

An Idle Point is defined as a point having a Normalized Reference Torque of 0 and a Normalized Reference Speed of 0 and an engine tested as having a manual transmission has a CITT of 0. Point deletion may be applied either to the whole or to any part of the cycle. EXPSTB='00'

(4)(i) For petroleum-fueled and methanol-fueled diesel engines, the integrated brake horsepower-hour for each cycle (cold and hot start) shall be between −15 percent and +5 percent of the integrated brake horsepower-hour for the reference cycle, or the test is void.

(ii) For gasoline-fueled and methanol-fueled Otto-cycle engines, the integrated brake horsepower-hour of the feedback cycle shall be within 5 percent of the integrated brake horsepower-hour of the reference cycle for the cold cycle, or the test is void. The tolerance for the hot cycle shall be 4 percent.

(5) If a dynamometer test run is determined to be statistically or experimentally void, corrective action shall be taken. The engine shall then be allowed to cool (naturally or forced) and the dynamometer test rerun per § 86.1337 or be restarted at § 86.1336–84(e).

(d) For petroleum-fueled and methanol-fueled diesel engines, all reference torque values specified (in paragraph (f)(2) of appendix I to this part) as ''closed throttle'' shall be deleted from the calculation of cycle torque and power validation statistics.

[54 FR 14604, Apr. 11, 1989, as amended at 62 FR 47134, Sept. 5, 1997]

§ 86.1341–98 Test cycle validation criteria.

Section 86.1341–98 includes text that specifies requirements that differ from § 86.1341–90. Where a paragraph in § 86.1341–90 is identical and applicable to § 86.1341–98, this may be indicated by specifying the corresponding paragraph and the statement ''[Reserved]. For guidance see § 86.1341–90''

(a) Through (b)(2) [Reserved]. For guidance see § 86.1341–90.

(b)(3) All feedback torques due to accessory loads, either actual or simulated as defined in § 86.1327–90 (d)(4), shall be excluded from both cycle validation and the integrated work used for emissions calculations.

(4) For reference idle portions of the cycle where CITT is not applied, use measured torque values for cycle validation and the reference torque values for calculating the brake horsepower-hour value used in the emission calculations. For reference idle portions of the cycle where CITT is applied, use measured torque values for cycle validation and calculating the brake horsepower-hour value used in the emission calculations.

(c) Through (d) [Reserved]. For guidance see § 86.1341–90.

[62 FR 47135, Sept. 5, 1997]

§ 86.1342–90 Calculations; exhaust emissions.

(a) The final reported transient emission test results should be computed by using the following formula:

ER06OC93.232

Where:

(1) A_{WM} = Weighted mass emission level (HC, CO, CO_2, or NO_X) in grams per brake horsepower-hour and, if appropriate, the weighted mass total hydrocarbon equivalent, in grams per brake horsepower-hour.

(2) g_C = Mass emission level in grams or grams carbon mass equivalent, measured during the cold start test.

(3) g_H = Mass emission level in grams or grams carbon mass equivalent, measured during the hot start test.

(4) $BHP - hr_C$ = Total brake horsepower-hour (brake horsepower integrated over time) for the cold start test.

(5) $BHP\text{-}hr_H$ = Total brake horsepower-hour (brake horsepower integrated over time) for the hot start test.

(b) The mass of each pollutant for the cold start test and the hot start test for bag measurements and diesel continuously heated sampling system measurements is determined from the following equations:

(1) Hydrocarbon mass:

$HC_{mass} = V_{mix} \times Density_{HC} \times (HC_{conc}/10^6)$

(2) Oxides of nitrogen mass:

$NOx_{mass} = V_{mix} \times Density_{NO2} \times K_H \times (NOx_{conc}/10^6)$

(3) Carbon monoxide mass:

$CO_{mass} = V_{mix} \times Density_{CO} \times (CO_{conc}/10^6)$

(4) Carbon dioxide mass:

$CO_{2mass} = V_{mix} \times Density\ CO_2 \times (CO_{2conc}/10^2)$

(5) Methanol mass:

$CH3OH_{mass} = V_{mix} \times Density\ _{CH3OH} \times (CH3OH_{conc}/10^6)$

(6) Formaldehyde mass:

$HCHO_{mass} = V_{mix} \times Density_{HCHO} \times (HCHO_{conc}/10^6)$

(7) Total hydrocarbon equivalent mass:

(i)

ER06OC93.231

(c) The mass of each pollutant for the cold start test and the hot start test for flow compensated sample systems is determined from the following equations:

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(d) Meaning of symbols:

(1)(i) HC_{mass} = Hydrocarbon emissions, in grams per test phase.

(ii) $Density_{HC}$ = Density of hydrocarbons = 16.33 g/ft^3 (0.5768 kg/m^3) for gasoline and the gasoline fraction of methanol-fuel, and may be used for petroleum and the petroleum fraction of methanol diesel fuel if desired, 16.42 g/ft^3 (0.5800 kg/m^3) for #l petroleum diesel fuel and 16.27 g/ft^3 (0.5746 kg/m^3) for #2 diesel, assuming an average carbon to hydrogen ratio of 1:1.85 for gasoline, 1:1.93 for #1 petroleum diesel fuel and 1:1.80 for #2 petroleum diesel fuel at 68 °F (20 °C) and 760 mm Hg (101.3 kPa) pressure.

(iii)(A) HC_{conc} = Hydrocarbon concentration of the dilute exhaust sample corrected for background, in ppm carbon equivalent (i.e., equivalent propane × 3).

(B) $HC_{conc} = HC_e - HC_d(1 - (1/DF))$
Where:

(iv)(A) HC_e = Hydrocarbon concentration of the dilute exhaust bag sample or, for diesel continuous heated sampling systems, average hydrocarbon concentration of the dilute exhaust

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sample as determined from the integrated HC traces, in ppm carbon equivalent. For flow compensated systems $(HC_e)_i$ is the instantaneous concentration.

(B) For petroleum-fueled engines, HC_e is the FID measurement.

(C) For methanol-fueled engines:

$HC_e = FID\ HC_e - (r)C_{CH3OHe}$

(v) FID HC_e = Concentration of hydrocarbon plus methanol in dilute exhaust as measured by the FID, ppm carbon equivalent.

(vi) r = FID response to methanol.

(vii) C_{CH3OHe} = Concentration of methanol in dilute exhaust as determined from the dilute exhaust methanol sample, ppm carbon.

(viii)(A) HC_d = Hydrocarbon concentration of the dilution air as measured, in ppm carbon equivalent.

(B) $HC_d = FID\ HC_d - (r)C_{CH3OHd}$

(ix) FID HC_d = Concentration of hydrocarbon plus methanol in dilution air as measured by the FID, ppm carbon equivalent.

(x) C_{CH3OHd} = Concentration of methanol in dilution air as determined from dilution air methanol sample in ppm carbon.

(2)(i) NOx_{mass} = Oxides of nitrogen emissions, in grams per test phase.

(ii) $Density_{NO2}$ = Density of oxides of nitrogen is 54.16 g/ft³ (1.913 kg/m³), assuming they are in the form of nitrogen dioxide, at 68 °F (20 °C) and 760 mm Hg (101.3 kPa) pressure.

(iii)(A) NOx_{conc} = Oxides of nitrogen concentration of the dilute exhaust sample corrected for background, in ppm.

(B) $NOx_{conc} = NOx_e - NOx_d [1 - (1/DF)]$

Where:

(iv) NOx_e = Oxides of nitrogen concentration of the dilute exhaust bag sample as measured, in ppm. For flow

compensated sample systems $(NOx_e)_i$ is the instantaneous concentration.

(v) NOx_d = Oxides of nitrogen concentration of the dilution air as measured, in ppm.

(3)(i) CO_{mass} = Carbon monoxide emissions, grams per test phase.

(ii) $Density_{CO}$ = Density of carbon monoxide is 32.97 g/ft³ (1.164 kg/m³), at 68 °F (20 °C) and 760 mm Hg (101.3 kPa) pressure.

(iii)(A) CO_{conc} = Carbon monoxide concentration of the dilute exhaust sample corrected for background, water vapor, and CO_2 extraction, ppm.

(B) $CO_{conc} = CO_e - CO_d[1 - (1/DF)]$

Where:

(iv) CO_e = Carbon monoxide concentration of the dilute exhaust bag sample volume corrected for water vapor and carbon dioxide extraction, in ppm. For flow compensated sample systems $(CO_e)_i$ is the instantaneous concentration.

(v)(A) $CO_e = (1 - 0.01925CO_{2e} - 0.000323R)CO_{em}$ for gasoline and petroleum diesel fuel, with hydrogen to carbon ratio of 1.85:1.

(B) $CO_e = [1 - (0.01 + 0.005HCR)\ CO_{2e} - 0.000323R]\ CO_{em}$ for methanol fuel, where HCR is hydrogen to carbon ratio as measured for the fuel used.

Where:

(vi) CO_{em} = Carbon monoxide concentration of the dilute exhaust sample as measured, in ppm.

(vii)(A) CO_{2e} = Carbon dioxide concentration of the dilute exhaust bag sample, in percent, if measured. For flow compensated sample systems, $(CO_{2e})_i$ is the instantaneous concentration. For cases where exhaust sampling of CO_2 is not performed, the following approximation is permitted:

(B)

er31au93.062

Where:

(C) α = Average carbon to hydrogen ratio, as specified by the Administrator.

(D) M′ = Fuel mass consumed during the test cycle.

(E) R = Relative humidity of the dilution air, percent.

(viii)(A) CO_d = Carbon monoxide concentration of the dilution air corrected for water vapor extraction, in ppm.

(B) $CO_d = (1 - 0.000323R)CO_{dm}$.

Where:

(ix) CO_{dm} = Carbon monoxide concentration of the dilution air sample as measured, in ppm.

NOTE: If a CO instrument which meets the criteria specified in § 86.1311 is used and the conditioning column has been deleted, CO_{em} must be substituted directly for CO_e, and CO_{dm} must be substituted directly for CO_d.

(4)(i) CO_{2mass} = Carbon dioxide emissions, in grams per test phase.

(ii) Density CO_2 = Density of carbon dioxide is 51.81 g/ft³ (1.830 kg/m³), at 68 °F (20 °C) and 760 mm Hg (101.3 kPa) pressure.

(iii) CO_{2conc} = Carbon dioxide concentration of the dilute exhaust sample corrected for background, in percent.

EC07JA94.024

(v)(A) C_{CH3OHd} = Methanol concentration in the dilution air, in ppm.

EC07JA94.025

(vi) C_{CH3OHR} = Concentration of methanol in standard sample for calibration of GC, µg/ml.

(vii) A_{CH3OHR} = GC peak area of standard sample.

(viii) T_{EM} = Temperature of methanol sample withdrawn from dilute exhaust, °R.

(ix) T_{DM} = Temperature of methanol sample withdrawn from dilution air, °R.

(x) P_B = Barometric pressure during test, mm Hg.

(xi) V_{EM} = Volume of methanol sample withdrawn from dilute exhaust, ft³.

(xii) V_{DM} = Volume of methanol sample withdrawn from dilution air, ft³.

(xiii) A_S = GC peak area of sample drawn from dilute exhaust.

(iv) $CO_{2mass} = CO_{2e} - CO_{2d}[1 - (1/DF)]$.

Where:

(v) CO_{2d} = Carbon dioxide concentration of the dilution air as measured, in percent.

(5)(i) CH_3OH_{mass} = Methanol emissions corrected for background, in grams per test phase.

(ii) Density$_{CH3OH}$ = Density of methanol is 37.71 g/ft³ (1.332 kg/m³), at 68 °F (20 °C) and 760 mm Hg (101.3kPa) pressure.

(iii)(A) CH_3OH_{conc} = Methanol concentration of the dilute exhaust corrected for background, in ppm.

(B) $CH_3OH_{conc} = C_{CH3OHe} - C_{CH3OHd} [1 - (1/DF)]$.

Where:

(iv)(A) C_{CH3OHe} = Methanol concentration in the dilute exhaust, in ppm.

(B)

(B)

(xiv) A_D = GC peak area of sample drawn from dilution air.

(xv) AV_S = Volume of absorbing reagent (deionized water) in impinger through which methanol sample from dilute exhaust is drawn, ml.

(xvi) AV_D = Volume of absorbing reagent (deionized water) in impinger through which methanol sample from dilution air is drawn, ml.

(xvii) 1 = first impinger.

(xviii) 2 = second impinger.

(6)(i) $HCHO_{mass}$ = Formaldehyde emissions corrected for background, grams per test phase.

(ii) Density$_{HCHO}$ = Density of formaldehyde is 35.36 g/ft³ (1.249 kg/m³), at 68 °F (20 °C) and 760 mmHg (101.3 kPa) pressure.

(iii)(A) $HCHO_{conc}$ = Formaldehyde concentration of the dilute exhaust corrected for background, ppm.

(B) $HCHO_{conc} = C_{HCHOe} - C_{HCHOd} [1 - (1/DF)]$.

EC07JA94.026

(v)(A) C_{HCHOd} = Formaldehyde concentration in dilution air, ppm.

EC07JA94.027

(vi) C_{FDE} = Concentration of DNPH derivative of formaldehyde from dilute exhaust sample in sampling solution, $\mu g/ml$.

(vii) V_{AE} = Volume of sampling solution for dilute exhaust formaldehyde sample, ml.

(viii)(A) Q = Ratio of molecular weights of formaldehyde to its DNPH derivative.

(B) Q = 0.1429.

(ix) T_{EF} = Temperature of formaldehyde sample withdrawn from dilute exhaust, °R.

(x) V_{SE} = Volume of formaldehyde sample withdrawn from dilute exhaust, ft³.

Where:

(iv)(A) C_{HCHOe} = Formaldehyde concentration in dilute exhaust, ppm.

(B)

(xi) P_B = Barometric pressure during test, mm Hg.

(xii) C_{FDA} = Concentration of DNPH derivative of formaldehyde from dilution air sample in sampling solution, $\mu g/ml$.

(xiii) V_{AA} = Volume of sampling solution for dilution air formaldehyde sample, ml.

(xiv) T_{DF} = Temperature of formaldehyde sample withdrawn from dilution air, °R.

(xv) V_{SA}=Volume of formaldehyde sample withdrawn from dilution air, ft³.

(7)(i) $DF=13.4/[CO_{2e}+(HC_e+CO_e)10^{-4}]$ for petroleum-fueled vehicles, or $DF=13.4/CO_{2e}$

EC07JA94.028

for methanol-fueled vehicles, where fuel composition is $C_X H_y O_z$ as measured for the fuel used.

(8)(i) K_H = Humidity correction factor.

(ii) For gasoline-fueled and methanol-fueled diesel engines: $K_H = 1/[1 - 0.0047 (H - 75)]$ (or for SI units, $K_H = 1/[1 - 0.0329(H - 10.71)]$).

(iii) For petroleum-fueled and methanol-fueled diesel engines: $K_H = 1/[1 - 0.0026 (H - 75)]$ (or for SI units $= 1/[1 - 0.0182 (H - 10.71)]$).

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Where:

(iv)(A) H = Absolute humidity of the engine intake air in grains (grams) of water per pound (kilogram) of dry air.

(B)(*1*) $H = [(43.478)R_i \times P_d]/[P_B - (P_d \times R_i/100)]$

(*2*) *For SI units,*

$H = [(6.211)R_i \times P_d]/[P_B - (P_d \times R_i/100)]$

(C) R_i = Relative humidity of the engine intake air, percent.

(D) P_d = Saturated vapor pressure, in mm Hg (kPa) at the engine intake air dry bulb temperature.

(E) P_B = Barometric pressure, in mm Hg (kPa).

(9)(i) V_{mix} = Total dilute exhaust volume in cubic feet per test phase corrected to standard conditions (528 °R) (293 °K) and 760 mm Hg (101.3 kPa).

(ii) $(V_{mix})_i$ = Instantaneous dilute exhaust volumetric flow rate (for compensated flow systems), ft³/sec.

(iii) T = Time interval (seconds) between samples in flow compensated systems.

(iv) T = Total sampling time (seconds).

(v) *For PDP–CVS:*

(A)

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(B) *For SI units,*

er31au93.068

Where:

(vi) V_o = Volume of gas pumped by the positive displacement pump, in cubic feet (cubic meters) per revolution. This volume is dependent on the pressure differential across the positive displacement pump.

(vii) N = Number of revolutions of the positive displacement pump during the test phase while samples are being collected.

(viii) P_B = Barometric pressure, mm Hg (kPa).

(ix) P_4 = Pressure depression below atmospheric measured at the inlet to the positive displacement pump, in mm Hg (kPa) (during an idle mode).

(x) T_p = Average temperature of dilute exhaust entering positive displacement pump during test, °R (°K).

(e) Sample calculation of mass values of exhaust emissions:

(1) Assume the following test results for a gasoline engine:

	Cold start cycle test results	Hot start cycle test results
V_{mix}	6924 ft³	6873 ft³.
R	30.2 percent	30.2 percent.
R_i	30.2 percent	30.2 percent.
P_B	735 mm Hg	735 mm Hg.
P_d	22.676 mm Hg	22.676 mm Hg.
HC_e	132.07 ppm C equiv	86.13 ppm C equiv.
NO_{xe}	7.86 ppm	10.98 ppm.
CO_{em}	171.22 ppm	114.28 ppm.
CO_{2e}	0.178 percent	0.381 percent.
HC_d	3.60 ppm C equiv	8.70 ppm C equiv.
NO_d	0.0 ppm	0.10 ppm.
CO_{dm}	0.89 ppm	0.89 ppm.
CO_{2d}	0.0 percent	0.038 percent.
BHP–hr	0.259	0.347.

Then:

(2) *Cold Start Test:*

(i) H
$= [(43.478)(30.2)(22.676)]/[735 - (22.676)(30.2)/100]$
$= 41$ grains of water per pound of dry air.

(ii) $K_H = 1/[1 - 0.0047(41 - 75)] = 0.862$

(iii) CO_e
$= [1 - 0.01925(.178) - 0.000323(30.2)]171.22$
$= 169.0$ ppm

(iv) $CO_d = [1 - 0.000323(30.2)] 0.89 = 0.881$ ppm

(v) DF
$= 13.4/[.178 + (132.07 + 169.0)(10^{-4})]$
$= 64.390$

(vi) HC_{conc}
$= 132.07 - 3.6[1 - (1/64.390)]$
$= 128.5$ ppm

(vii) HC_{mass}
$= 6924(16.33)(128.5/10^6)$
$= 14.53$ grams

(viii) NOx_{conc}
$= 7.86 - 0.0[1 - (1/64.390)]$
$= 7.86$ ppm

(ix) NOx_{mass}
$= 6924(54.16)(.862)(7.86/10^6)$
$= 2.54$ grams

(x) CO_{conc}
$= 169.0 - .881[1 - (1/64.390)]$
$= 168.0$ ppm

(xi) CO_{mass}
$= 6924(32.97)(168.0/10^6)$
$= 38.35$ grams

(xii) $CO_{2conc} = .178 - 0[1 - 1/64.390] = 0.178\%$

(xiii) $CO_{2mass}=6924(51.81)(.178/100)=639$ grams

(3) *Hot start test:* Similar calculations result in the following:

(i) HC_{mass} = 8.72 grams

(ii) NOx_{mass} = 3.49 grams

(iii) CO_{mass} = 25.70 grams

(iv) CO_{2mass} = 1226 grams

(4) Weighted mass emission results:

(i) HC_{wm} = 1/7(14.53) + 6/7(8.72)/1/7(0.259) + 6/7(0.347) = 28.6 grams/BHP−hr

(ii) NO_{Xwm} = 1/7(2.54) + 6/7(3.49)/1/7(0.259) + 6/7(0.347) = 10.0 grams/BHP−hr

(iii) CO_{wm} = 1/7(38.35) +6/7(25.70)/1/7(0.259) + 6/7(0.347) = 82.2 grams/BHP−hr

(iv) CO_{2wm} = 1/7(639) + 6/7(1226)/1/7(0.259) + 6/7(0.347) = 3415 grams/BHP−hr

(f) The final reported brake-specific fuel consumption (BSFC) shall be computed by use of the following formula:

ER06OC93.222

Where:

er31au93.069

Where:

(iii) HC_{mass} = Hydrocarbon emissions, in grams, for cold or hot start test.

(iv) CO_{mass} = Carbon monoxide emissions, in grams, for cold or hot start test.

(v) CO_{2mass} = Carbon dioxide emissions, in grams, for cold or hot start test.

(vi) α = The atomic hydrogen to carbon ratio of the fuel.

(vii)(A) R_2 = The grams of carbon in the fuel per gram of fuel.

(B) $R_2 = 12.011/[12.011 + \alpha(1.008)]$

(h) Sample calculation of brake-specific fuel consumption:

(1) Assume the following test results:

	Cold start cycle test results	Hot start cycle test results
BHP-hr	6.945	7.078
α	1.85	1.85
HC_{mass} (grams)	37.08	28.82
CO_{mass} (grams)	357.69	350.33

(1) BSFC = brake-specific fuel consumption in pounds of fuel per brake horsepower-hour (lbs/BHP–hr).

(2) M_C = mass of fuel, in lbs, used by the engine during the cold start test.

(3) M_H = mass of fuel, in lbs, used by the engine during the hot start test.

(4) $BHP–hr_C$ = total brake horsepower-hours (brake horsepower integrated with respect to time) for the cold start test.

(5) $BHP–hr_H$ = total brake horsepower-hours (brake horsepower integrated with respect to time) for the hot start test.

(g)(1) The mass of fuel for the cold start and hot start test is determined from mass fuel flow measurements made during the tests, or from the following equation:

$M = (G_s/R_2)(1/453.6)$

(2) Meaning of symbols:

(i) M = Mass of fuel, in lbs, used by the engine during the cold or hot start test.

(ii) G_s = Grams of carbon measured during the cold or hot start test:

	Cold start cycle test results	Hot start cycle test results
CO_{2mass} (grams)	5,419.62	5,361.32

Then:

(i) G_s for cold start test = [12.011/(12.011 + (1.008)(1.85))](37.08) + 0.429(357.69) + 0.273(5419.62) = 1665.10 grams

(ii) G_s for hot start test = [12.011/(12.011 + (1.008)(1.85))](28.82) + 0.429(350.33) + 0.273(5361.32) = 1638.88 grams

(iii) R_2 = 12.011/[12.011 + (1.008)1.85] = 0.866

(iv)(A) M_c = (1665.10/.866)(1/453.6) = 4.24 lbs (calculated), or

(B)   = 4.24 lbs (directly measured).

(v)(A) M_H = (1638.88/.866)(1/453.6) = 4.17 lbs (calculated), or

(B)   = 4.17 lbs (directly measured).

(2) Brake-specific fuel consumption results:

BSFC = $(1/7)(4.24) + (6/7)(4.17)/(1/7)(6.945) + (6/7)(7.078) = 0.592$ lbs of fuel/BHP–hr

(i) For dilute sampling systems which require conversion of as-measured dry concentrations to wet concentrations, the following equation shall be used for any combination of bagged, continuous, or fuel mass-approximated sample measurements (except for CO measurements made through conditioning columns, as explained in paragraph (d)(3) of this section):

Wet concentration = K_w × dry concentration.

Where:

(1)(i) For English units,

$K_w = 1 - (\alpha/200) \times CO_{2e}(') - ((1.608 \times H)/(7000 + 1.608 \times H))$

See paragraph (d)(1) of this section for α values.

(ii) For SI units,

$K_w = 1 - (\alpha/200) \times CO_{2e}(') - ((1.608 \times H)/(1000 + 1.608 \times H))$

See paragraph (d)(1) of this section for α values.

(2) $CO_{2e}(')$ = either CO_{2e} or CO_{2e}' as applicable.

(3)(i) H = Absolute humidity of the CVS dilution air, in grains (grams) of water per lb (kg) of dry air.

(ii) For English units,

$H' = [(43.478)R_i' \times P_d']/[P_B - (P_d' \times R_i'/100)]$

(iii) For SI units,

$H' = [(6.211)R_i' \times P_d']/[P_B - (P_d' \times R_i'/100)]$

(4) R_i = Relative humidity of the CVS dilution air, in percent.

(5) P_d = Saturated vapor pressure, in mm Hg (kPa) at the ambient dry bulb temperature of the CVS dilution air.

(6) P_B = Barometric pressure, mm Hg (kPa).

[54 FR 14605, Apr. 11, 1989, as amended at 62 FR 47135, Sept. 5, 1997]

§ 86.1342–94 Calculations; exhaust emissions.

Section 86.1342–94 includes text that specifies requirements that differ from § 86.1342–90. Where a paragraph in § 86.1342–90 is identical and applicable to § 86.1342–94, this may be indicated by specifying the corresponding paragraph and the statement ''[Reserved]. For guidance see § 86.1342–90.''

(a) introductory text [Reserved]. For guidance see § 86.1342–90.

(a)(1) A_{WM}=Weighted mass emission level (HC, CO, CO_2, or NO_X) in grams per brake horsepower-hour and, if appropriate, the weighted mass total hydrocarbon equivalent, formaldehyde, or non-methane hydrocarbon emission level in grams per brake horsepower-hour.

(a)(2) through (b)(7) [Reserved]. For guidance see § 86.1342–90.

(b)(8) Non-methane hydrocarbon mass:

$NMHC_{mass} = V_{mix} \times Density_{NMHC} \times (NMHC_{conc}/1,000,000)$

(c) through (d)(1)(i) [Reserved]. For guidance see § 86.1342–90.

(d)(1)(ii) $Density_{HC}$ = Density of hydrocarbons.

(A) For gasoline and the gasoline fraction of methanol-fuel, and may be used for petroleum and the petroleum fraction of methanol diesel fuel if desired; 16.33 g/ft³-carbon atom (0.5768 kg/m³-carbon atom).

(B) For #1 petroleum diesel fuel; 16.42 g/ft³-carbon atom (0.5800 kg/m³-carbon atom).

(C) For #2 diesel 16.27 g/ft³-carbon atom (0.5746 kg/m³-carbon atom). Average carbon to hydrogen ratios of 1:1.85 for gasoline, 1:1.93 for #1 petroleum diesel fuel and 1:1.80 for #2 petroleum diesel fuel are assumed at 68 °F (20 °C) and 760 mm Hg (101.3 kPa) pressure.

(D) For natural gas and liquified petroleum gas-fuel; 1.1771 (12.011+H/C (1.008)) g/ft³-carbon atom (0.04157 (12.011+H/C (1.008)) kg/m³-carbon atom) where H/C is hydrogen to carbon ratio of the hydrocarbon components of the test fuel, at 68 °F (20 °C) and 760 mm Hg (101.3 kPa) pressure.

(d)(1)(iii) through (d)(1)(iv)(A) [Reserved]. For guidance see § 86.1342–90.

(d)(1)(iv)(B) For petroleum-fueled, natural gas-fueled and liquified petroleum gas-fueled engines, HC_e is the FID measurement.

(d)(1)(iv)(C) through (d)(3)(v)(A) [Reserved]. For guidance see § 86.1342–90.

(d)(3)(v)(B) $CO_e = [1 - (0.01 + 0.005HCR) CO_{2e} - 0.000323R] CO_{em}$ for methanol-fuel, natural gas-fuel and liquified petroleum gas-fuel where HCR is hydrogen to carbon ratio as measured for the fuel used.

Where:

(d)(3)(vi) through (d)(5)(iii)(B) [Reserved]. For guidance see §86.1342–90.

ER30JN95.039

(v)(A) C_{CH3OHd}=Methanol concentration in the dilution air, in ppm

(B)

ER30JN95.040

(vi) T_{EM}=Temperature of methanol sample withdrawn from dilute exhaust, °R

(vii) T_{DM}=Temperature of methanol sample withdrawn from dilution air, °R

(viii) P_B=Barometric pressure during test, mm Hg.

(ix) V_{EM}=Volume of methanol sample withdrawn from dilute exhaust, ft³

(x) V_{DM}=Volume of methanol sample withdrawn from dilution air, ft³

(xi) C_S=GC concentration of sample drawn from dilute exhaust

(xii) C_D=GC concentration of sample drawn from dilution air

ER30JN95.041

(d)(8)(i) [Reserved]. For guidance see §86.1342–90.

(d)(8)(ii) For Otto-cycle engines: K_H=1/[1–0.0047(H–75)] (or for SI units, K_H=1/[1–0.0329(H–10.71)]).

(iii) For diesel engines: K_H = 1/[1–0.0026 (H–75)] (or for SI units = 1/[1–0.0182 (H–10.71)]).

Where:

(d)(5)(iv)(A) C_{CH3OHe}=Methanol concentration in the dilute exhaust, in ppm.

(B)

(B)

(xiii) AV_S=Volume of absorbing reagent (deionized water) in impinger through which methanol sample from dilute exhaust is drawn, ml

(xiv) AV_D=Volume of absorbing reagent (deionized water) in impinger through which methanol sample from dilution air is drawn, ml

(xv) 1=first impinger.

(xvi) 2=second impinger.

(d)(6)(i) through (d)(7)(i) [Reserved]. For guidance see §86.1342–90.

(d)(7)(ii) For methanol-fueled vehicles, where fuel composition is $C_X H_y O_z$ as measured, or calculated, for the fuel used:

(d)(8)(iv) through (d)(9)(x) [Reserved]. For guidance see §86.1342–90.

(d)(10)(i) $NMHC_{conc} = HC_{conc}–CH4_{conc}$

(ii) $Density_{NMHC}$ = The density of non-methane hydrocarbon, is 1.1771(12.011 + H/C (1.008)) g/ft³-carbon atom (0.04157(12.011 + H/C (1.008))kg/m³-carbon atom), where H/C is the hydrogen to carbon ratio of the non-methane hydrocarbon components of the test fuel, at

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68 °F (20 °C) and 760 mm Hg (101.3 kPa) pressure.

(iii)(A) CH_{4conc} = Methane concentration of the dilute exhaust sample corrected for background, in ppm carbon equivalent.

(B) $CH_{4conc} = r_{CH4} \times (CH_{4e}-CH_{4d}(1-1/DF))$

Where:

(*1*) CH_{4e} = Methane exhaust bag concentration in ppm carbon equivalent.

(*2*) CH_{4d} = Methane concentration of the dilution air in ppm carbon equivalent.

(*3*) r_{CH4} = HC FID response to methane for natural gas-fueled vehicles as measured in § 86.1321 (d).

(e) Through (i) [Reserved]. For guidance see § 86.1342–90.

[59 FR 48534, Sept. 21, 1994, as amended at 60 FR 34375, June 30, 1995; 62 FR 47135, Sept. 5, 1997]

§ 86.1343–88 Calculations; particulate exhaust emissions.

(a) The final reported transient emission test results shall be computed by use of the following formula:

er31au93.070

(1) P_{mass} = Mass of particulate emitted per test phase, grams per test phase. ($P_H = P_{mass}$ for the hot-start test and $P_C = P_{mass}$ for the cold-start test.

(2) V_{mix} = Total dilute exhaust volume corrected to standard conditions (528° R (293° K) and 760 mm Hg (101.3 kPa)), cubic feet per test phase. For a PDP–CVS:

ER06OC93.226

in SI units,

ER06OC93.227

Where:

ER06OC93.234

(1) P_{wm} = Weighted mass particulate, grams per brake horsepower-hour.

(2) P_C = Mass particulate measured during the cold-start test, grams.

(3) P_H = Mass particulate measured during the hot-start test, grams.

(4) BHP-hr_C = Total brake horsepower-hour (brake horsepower integrated with respect to time) for the cold-start test.

(5) BHP-hr_H = Total brake horsepower-hour (brake horsepower integrated with respect to time) for the hot-start test.

(b) The mass of particulate for the cold-start test and the hot-start test is determined from the following equation:

(2)(i)(A) For a CFV–CVS: V_{mix} = Total dilute exhaust volume corrected to standard conditions (293 °K (20 °C) and 101.3 kPa (760 mm Hg)), cubic feet per test phase.

(B) For a PDP–CVS:

ER05SE97.006

in SI units,

ER05SE97.007

Where:

(ii) V_o = Volume of gas pumped by the positive displacement pump, cubic feet (cubic meters) per revolution. This volume is dependent on the pressure

differential across the positive displacement pump.

(iii) N = Number of revolutions of the positive displacement pump during the test phase while samples are being collected.

(iv) P_B = Barometric pressure, mm Hg (kPa).

(v) P_4 = Pressure depressions below atmospheric measured at the inlet to the positive displacement pump (during an idle mode), mm Hg (kPa).

(vi) T_p = Average temperature of dilute exhaust entering the positive displacement pump during test, °R (°K).

(3) V_{sf} = Total volume of sample removed from the primary dilution tunnel, cubic feet at standard conditions.

(i) For a single-dilution system:

ER06OC93.228

Where:

(A) V_{as} = Actual volume of dilute sample removed from the primary-dilution tunnel, cubic feet.

(B) P_B = Barometric pressure, mm Hg.

(C) P_{is} = Pressure elevation above ambient measured at the inlet to the dilute exhaust sample gas meter or flow instrumentation, mm Hg. (For most gas meters or flow instruments with unrestricted discharge, P_{is} is negligible and can be assumed = 0.)

(D) T_{is} = Average temperature of the dilute exhaust sample at the inlet to the gas meter or flow instrumentation, °R.

(E) V_{sf} may require correction according to §86.1320–87(a)(6).

(ii) For a double-dilution system:

$$V_{sf} = V_{vf} - V_{pf}'$$

Where:

er31au93.071

(B) V_{av} = Actual volume of double diluted sample which passed through the particulate filter, cubic feet.

(C) P_B = Barometric pressure, mm Hg.

(D) P_{iv} = Pressure elevation above ambient measured at the inlet to the sample gas meter located at the exit side of the secondary-dilution tunnel, mm Hg. (For most gas meters with unrestricted discharge P_{iv} is negligible and can be assumed = 0.)

(E) T_{iv} = Average temperature of the dilute exhaust sample at the inlet to the exit side gas meter or flow instrumentation, °R.

ER06OC93.229

(G) V_{ap} = Actual volume of secondary dilution air, cubic feet.

(H) P_a = Barometric pressure, mm Hg.

(I) P_{ip} = Pressure elevation above ambient measured at the inlet to the sample gas meter or flow instrumentation located at the inlet side of the secondary dilution tunnel, mm Hg. (For most gas meters with unrestricted discharge P_{ip} is negligible and can be assumed = 0.)

(J) T_{ip} = Average temperature of the secondary dilution air at the inlet to the inlet side gas meter or flow instrumentation, °R.

(K) Both V_{vf} and V_{pf} may require correction according to §86.1320–87(a)(6). These corrections must be applied before V_{sf} is determined.

(4) P_f = Mass of particulate on the sample filter (or sample and back-up filters if the back-up filter is required to be included, see §86.1339–87(g) for determination), grams per test phase.

(5) P_{bf} = Net weight of particulate on the background particulate filter, grams.

ER06oc93.230

Where:

(i) V_{ab} = Actual volume of primary dilution air sampled by background particulate sampler, cubic feet.

(ii) P_{ib} = Pressure elevation above ambient measured at the inlet to the background gas meter or flow instrument, mm Hg. (for most gas meters or flow instruments with unrestricted discharge, P_{ib} is negligible and can be assumed = 0.)

(iii) T_{ib} = Average temperature of the background sample at the inlet to the gas meter or flow instrument, °R.

(7) For definition of DF see § 86.1342–84(d)(5).

(8)(i) Real time flow rate measurement and calculating devices are permitted under these regulations. The appropriate changes in the above calculations shall be made using sound engineering principles.

(ii) Other systems and options, as permitted under these regulations, may require calculations other than these, but these must be based on sound engineering principles and be approved in advance by the Administrator at the time the alternate system is approved.

(Secs. 202, 203, 206, 207, 208, 301a, Clean Air Act, as amended; 42 U.S.C. 7521, 7522, 7525, 7541, 7542, 7601a)

[50 FR 10706, Mar. 15, 1985, as amended at 52 FR 47876, Dec. 16, 1987; 62 FR 47135, Sept. 5, 1997]

§ 86.1344–90 Required information.

(a) The required test data shall be grouped into the following three general categories:

(1) *Engine set up and descriptive data.* These data must be provided to the EPA supervisor of engine testing for each engine sent to the Administrator for confirmatory testing prior to the initiation of engine set-up. These data are necessary to ensure that EPA test personnel have the correct data in order to set up and test the engine in a timely and proper manner. These data are not required for tests performed by the manufacturers.

(2) *Pre-test data.* These data are general test data that must be recorded for each test. The data are of a more descriptive nature such as identification of the test engine, test site number, etc. As such, these data can be recorded at any time within 24 hours of the test.

(3) *Test data.* These data are physical test data that must be recorded at the time of testing.

(b) When requested, data shall be supplied in the format specified by the Administrator.

(c) *Engine set-up data.* Because specific test facilities may change with time, the specific data parameters and number of items may vary. The Application Format for Certification for the

applicable model year will specify the exact requirements. In general, the following types of data will be required:

(1) Engine manufacturer.

(2) Engine system combination.

(3) Engine code and CID.

(4) Engine identification number.

(5) Applicable engine model year.

(6) Engine fuel type.

(7) Recommended oil type.

(8) Exhaust pipe configuration, pipe sizes, etc.

(9) Curb or low idle speed.

(10) Dynamometer idle speed. (Automatic transmission engines only.)

(11) Engine parameter specifications such as spark timing, operating temperature, advance curves, etc.

(12) Engine performance data, such as maximum BHP, previously measured rated rpm, fuel consumption, governed speed, etc.

(13) Recommended start-up procedure.

(14) Maximum safe engine operating speed.

(15) Number of hours of operation accumulated on engine.

(16) Manufacturer's recommended inlet depression limit and typical in-use inlet depression level.

(17) Exhaust system:

(i) *Petroleum-fueled and methanol-fueled diesel engines:*

(A) Header pipe inside diameter.

(B) Tailpipe inside diameter.

(C) Minimum distance in-use between the exhaust manifold flange and the exit of the chassis exhaust system.

(D) Manufacturer's recommended maximum exhaust backpressure limit for the engine.

(E) Typical backpressure, as determined by typical application of the engine.

(F) Minimum backpressure required to meet applicable noise regulations.

(ii) *Gasoline-fueled and methanol-fueled Otto-cycle engines:* Typical in-use backpressure in vehicle exhaust system.

(d) *Pre-test data.* The following data shall be recorded, and reported to the Administrator for each test conducted for compliance with the provisions of CFR part 86, subpart A:

(1) Engine-system combination.

(2) Engine identification.

(3) Instrument operator(s).

(4) Engine operator(s).

(5) Number of hours of operation accumulated on the engine prior to beginning the test sequence (Figure N84–10).

(6) Identification and specifications of test fuel used.

(7) Date of most recent analytical assembly calibration.

(8) All pertinent instrument information such as tuning, gain, serial numbers, detector number, calibration curve number, etc. As long as this information is traceable, it may be summarized by system or analyzer identification numbers.

(e) *Test data.* The physical parameters necessary to compute the test results and ensure accuracy of the results shall be recorded for each test conducted for compliance with the provisions of 40 CFR part 86, subpart A. Additional test data may be recorded at the discretion of the manufacturer. Extreme details of the test measurements such as analyzer chart deflections will generally not be required on a routine basis to be reported to the Administrator for each test, unless a dispute about the accuracy of the data arises. The following types of data shall be required to be reported to the Administrator. The Application Format for Certification for the applicable model year will specify the exact requirements which may change slightly from year to year with the addition or deletion of certain items.

(1) Date and time of day.

(2) Test number.

(3) Engine intake air or test cell temperature.

(4) Barometric pressure. (A central laboratory barometer may be used: *Provided,* that individual test cell barometric pressures are shown to be within ±0.1 percent of the barometric pressure at the central barometer location.)

(5) Engine intake or test cell and CVS dilution air humidity.

(6) Maximum torque versus speed curve as determined in §86.1332, with minimum and maximum engine speeds, and a description of the mapping technique used.

(7) Measured maximum horsepower and maximum torque speeds.

(8) Measured maximum horsepower and torque.

(9) Measured high idle engine speed (governed petroleum-fueled and methanol-fueled diesel engines only).

(10) Measured fuel consumption at maximum power and torque (petroleum-fueled and methanol-fueled diesel engines only).

(11) Cold-soak time interval and cool down procedures.

(12) Temperature set point of the heated continuous analysis system components (if applicable).

(13) Test cycle validation statistics as specified in §86.1341 for each test phase (cold and hot).

(14) Total CVS flow rate with dilution factor for each test phase (cold and hot).

(15) Temperature of the dilute exhaust mixture and secondary dilution air (in the case of a double dilution system) at the inlet to the respective gas meter(s) or flow instrumentation used for particulate sampling.

(16) The maximum temperature of the dilute exhaust mixture immediately ahead of the particulate filter.

(17) Sample concentrations (background corrected) for HC, CO, CO_2, and NO_X for each test phase (cold and hot).

(18) *For methanol-fueled vehicles:*

(i) Volume of sample passed through the methanol sampling system and the volume of deionized water in each impinger.

(ii) The methanol concentration in the reference sample and the peak area from the GC analysis of the reference sample.

(iii) The peak area of the GC analyses of the test samples (methanol).

(iv) Volume of sample passed through the formaldehyde sampling system.

(v) The formaldehyde concentration in the reference sample and the peak area from the LC analysis of the reference sample.

(vi) The peak area of the LC analysis of the test sample (formaldehyde).

(vii) Specification of the methanol-fuel used during testing.

(19) The stabilized pre-test weight and post-test weight of each particulate sample and back-up filter or pair of filters.

(20) Brake specific emissions (g/BHP-hr) for HC, CO, NO_X and, if applicable, THCE, CH_3OH and HCHO for methanol-fueled vehicles for each test phase (cold and hot).

(21) The weighted (cold and hot) brake specific emissions (g/BHP-hr) for the total test.

(22) The weighted (cold and hot) carbon balance or mass-measured brake specific fuel consumption for the total test.

(23) The number of hours of operation accumulated on the engine after completing the test sequences described in Figure N84–10.

[54 FR 14610, Apr. 11, 1989]

§ 86.1344–94   Required information.

(a) The required test data shall be grouped into the following three general categories:

(1) *Engine set up and descriptive data.* These data must be provided to the EPA supervisor of engine testing for each engine sent to the Administrator for confirmatory testing prior to the initiation of engine set-up. These data are necessary to ensure that EPA test personnel have the correct data in order to set up and test the engine in a timely and proper manner. These data are not required for tests performed by the manufacturers.

(2) *Pre-test data.* These data are general test data that must be recorded for each test. The data are of a more descriptive nature such as identification of the test engine, test site number, etc. As such, these data can be recorded at any time within 24 hours of the test.

(3) *Test data.* These data are physical test data that must be recorded at the time of testing.

(b) When requested, data shall be supplied in the format specified by the Administrator.

(c) *Engine set-up data.* Because specific test facilities may change with time, the specific data parameters and number of items may vary. The Application Format for Certification for the applicable model year will specify the exact requirements. In general, the following types of data will be required:

(1) Engine manufacturer.

(2) Engine system combination.

(3) Engine code and CID.

(4) Engine identification number.

(5) Applicable engine model year.

(6) Engine fuel type.

(7) Recommended oil type.

(8) Exhaust pipe configuration, pipe sizes, etc.

(9) Curb or low idle speed.

(10) Dynamometer idle speed (automatic transmission engines only).

(11) Engine parameter specifications such as spark timing, operating temperature, advance curves, etc.

(12) Engine performance data, such as maximum BHP, previously measured rated rpm, fuel consumption, governed speed, etc.

(13) Recommended start-up procedure.

(14) Maximum safe engine operating speed.

(15) Number of hours of operation accumulated on engine.

(16) Manufacturer's recommended inlet depression limit and typical in-use inlet depression level.

(17) Exhaust system:

(i) *Diesel engines:*

(A) Header pipe inside diameter.

(B) Tailpipe inside diameter.

(C) Minimum distance in-use between the exhaust manifold flange and the exit of the chassis exhaust system.

(D) Manufacturer's recommended maximum exhaust backpressure limit for the engine.

(E) Typical backpressure, as determined by typical application of the engine.

(F) Minimum backpressure required to meet applicable noise regulations.

(ii) *Otto-cycle engines:* Typical in-use backpressure in vehicle exhaust system.

(d) *Pre-test data.* The following data shall be recorded and reported to the Administrator for each test conducted for compliance with the provisions of subpart A of this part:

(1) Engine-system combination.

(2) Engine identification.

(3) Instrument operator(s).

(4) Engine operator(s).

(5) Number of hours of operation accumulated on the engine prior to beginning the test sequence (Figure N84–10).

(6) Identification and specifications of test fuel used.

(7) Date of most recent analytical assembly calibration.

(8) All pertinent instrument information such as tuning, gain, serial numbers, detector number, calibration curve number, etc. As long as this information is traceable, it may be summarized by system or analyzer identification numbers.

(e) *Test data.* The physical parameters necessary to compute the test results and ensure accuracy of the results shall be recorded for each test conducted for compliance with the provisions of subpart A of this part. Additional test data may be recorded at the discretion of the manufacturer. Extreme details of the test measurements such as analyzer chart deflections will generally not be required on a routine basis to be reported to the Administrator for each test, unless a dispute about the accuracy of the data arises. The following types of data shall be required to be reported to the Administrator. The Application Format for Certification for the applicable model year will specify the exact requirements which may change slightly from year to year with the addition or deletion of certain items.

(1) Date and time of day.

(2) Test number.

(3) Engine intake air or test cell temperature.

(4) Barometric pressure. (A central laboratory barometer may be used: *Provided,* that individual test cell barometric pressures are shown to be within ±0.1 percent of the barometric pressure at the central barometer location.)

(5) Engine intake or test cell and CVS dilution air humidity.

(6) Maximum torque versus speed curve as determined in §86.1332, with minimum and maximum engine speeds, and a description of the mapping technique used.

(7) Measured maximum horsepower and maximum torque speeds.

(8) Measured maximum horsepower and torque.

(9) Measured high idle engine speed (governed diesel engines only).

(10) Measured fuel consumption at maximum power and torque (diesel engines only).

(11) Cold-soak time interval and cool down procedures.

(12) Temperature set point of the heated continuous analysis system components (if applicable).

(13) Test cycle validation statistics as specified in §86.1341 for each test phase (cold and hot).

(14) Total CVS flow rate with dilution factor for each test phase (cold and hot).

(15) Temperature of the dilute exhaust mixture and secondary dilution air (in the case of a double dilution system) at the inlet to the respective gas meter(s) or flow instrumentation used for particulate sampling.

(16) The maximum temperature of the dilute exhaust mixture immediately ahead of the particulate filter.

(17) Sample concentrations (background corrected) for HC, CO, CO_2 and NO_x for each test phase (cold and hot).

(18) For engines requiring methanol and/or formaldehyde measurement (as applicable):

(i) Volume of sample passed through the methanol sampling system and the volume of deionized water in each impinger.

(ii) The methanol concentration of the GC analyses of the test samples, μg/ml.

(iii) Volume of sample passed through the formaldehyde sampling system.

(iv) The formaldehyde concentration of the LC analysis of the test sample, μg/ml.

(v) Specification of the methanol test fuel, or fuel mixtures, used during testing.

(vi) A continuous measurement of the dew point of the raw and diluted exhaust. This requirement may be omitted if the temperatures of all heated lines are kept above 220 °F, or if the manufacturer performs an engineering analysis demonstrating that the temperature of the heated systems remains above the maximum dew point of the gas stream throughout the course of the test.

(19) For natural gas-fueled engines: Composition, including all carbon containing compounds; *e.g.*, CO_2, of the natural gas-fuel used during the test.

C_1 and C_2 compounds shall be individually reported. C_3 and heavier compounds, and C_6 and heavier compounds may be reported as a group.

(20) For liquefied petroleum gas-fueled engines: Composition of the liquefied petroleum gas-fuel used during the test. Each hydrocarbon compound present, through C_4 compounds, shall be individually reported. C_5 and heavier hydrocarbons may be reported as a group.

(21) The stabilized pre-test weight and post-test weight of each particulate sample and back-up filter or pair of filters.

(22) Brake specific emissions (g/BHP–hr) for HC, CO, NO_X, and, if applicable NMHC, NMHCE, THCE, CH_3OH, and HCHO for each test phase (cold and hot).

(23) The weighted (cold and hot) brake specific emissions (g/BHP-hr) for the total test.

(24) The weighted (cold and hot) carbon balance or mass-measured brake specific fuel consumption for the total test.

(25) The number of hours of operation accumulated on the engine after completing the test sequences described in Figure N84–10.

[59 FR 48535, Sept. 21, 1994, as amended at 60 FR 34376, June 30, 1995; 62 FR 54730, Oct. 21, 1997]